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ENGINEERING:

An Illustrated Weekly Journal.

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The Corporation do not bind themselves to accept the lowest or any Tender.

W. H. ANDREW, Town Clerk.

Town Hall, St. Helens, April, 1920. F 813

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Reference, Gen. 2365.

Tenders close at Ten a.m., on 5th May next.

NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 3s., post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. F 866

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A charge, which will not be returned, will be made of 40/- for each copy of the Specification. Copies of the Drawings may be obtained at the Office of ROBERT WHITE, Esq., M.Inst.C.E., Consulting Engineer to the Company, 3, Victoria Street, Westminster, S.W.

By Order, W. B. REYNOLDS, for Managing Director.

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NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 3s. post free, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. F 934

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Assistant Works Manager

REQUIRED for general engineering works in India. Good prospects for suitable man aged about 26, single.—Reply fully stating experience, age and salary required, to Z. W. 556, care of Messrs. DEACON'S, Leadenhall Street, London, E.C. F 930

Engineer, able to Start and

Erect SUGAR PLANT in India.—Address, stating age, experience and salary, F 794, Offices of ENGINEERING.

CITY OF MANCHESTER.

The Electricity Committee of the Manchester Corporation

Require the Services of a

RESIDENT ENGINEER, to act under the direction of the Consulting Engineers, on the construction of their new Generating Station at Barton, near Manchester, including road diversion, canal dock and culverts.

Candidates should have experience in heavy engineering construction on public works and preferably some experience with a contractor.

Applications, stating age, experience, and salary required, accompanied by references, to be addressed to the CHAIRMAN OF THE ELECTRICITY COMMITTEE, Town Hall, Manchester, endorsed "Resident Engineer," and delivered not later than Twelve o'clock noon, on Wednesday, the 21st April, 1920.

THOMAS HUDSON, Town Clerk.

1st April, 1920. F 798

Chief Ships' Draughts-

MAN REQUIRED by the SINGAPORE HARBOUR BOARD for a period of three years, with possible extension. Salary, 600 dollars per month (the present exchange value of the dollar is two shillings and fourpence, but this rate is liable to alteration).

Quarters free of rent, and free passages.

Candidates, age about 35, who must have served in some branch of H.M. Forces during the late war, unless their reasons for not doing so are entirely satisfactory, and who possess a first-class theoretical and practical experience in the design and construction of light craft and coasting steamers, and have had experience in charge of a Drawing Office, should apply by letter within one week of the date of this advertisement, stating age, whether married or single, and full particulars of experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, and quoting M/9737. F 915

Assistant Engineer

(3rd Grade) REQUIRED for service on the LAGOS HARBOUR WORKS, NIGERIA. Salary £375–£10–£425 per annum with a War Bonus of £120 a year. The question of increasing the salaries of Nigerian Government officials on the withdrawal of the War Bonus is at present under consideration. Free quarters and first-class passages. Liberal leave in England on full salary after each tour of 8 to 12 months' residential service. Candidates, age 23–40, who are fully qualified Civil Engineers, and have had experience on an Engineer's or Contractor's staff in the actual construction of Harbour Works, should apply in writing not later than one week from the date of this advertisement, giving brief details of age and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/Nigeria 9668. Candidates must have served in some branch of H.M. Forces during the late war, unless satisfactory reasons for not doing so can be furnished. F 919

STUDY OF FLIGHT VORTICES.

By F. W. CALDWELL and E. N. FALES.

THE experiments presented in this paper have resulted from studies extending through a number of years towards a means of visualising the obscure aerodynamic phenomena underlying manflight. In the early days of aerodynamical discovery interest was centred on the effect rather than on the nature of aerodynamic phenomena, thorough analysis being left for a later date, as is so frequently the case in the history of new sciences. When manflight was attained, no great advance in the physical conception of aerodynamics was signalised, but rather there was achieved a happy imitation of the birds. Because air has always been invisible, mankind has, until recently, had little knowledge of how it behaved. Now that flight has been accomplished we begin to experience a distinct need, as aeronautical engineers, for more facts regarding dynamic sustentation by the air. In the past we have been forced to content ourselves with vague notions of the eddies, whirls, wake deflections, tip effects, &c., associated with the passage of a wing through the air. The meagreness of the recorded phenomena has discouraged widespread attempts at analysis, and only the mathematicians have successfully brought the problem into order. They have, in lack of empirical material, built up a fabric whose fibres were borrowed from older and more general physical conceptions. The pure theory thus adduced has shown every indication of soundness, but in the past the engineers have been baffled in their attempts to bring the works of such men as Helmholtz, Kirchhoff, Lord Rayleigh, Lanchester, Bothezat, &c., out of the theoretical stage, and the mathematical conceptions have excited interest only among the initiated few. The majority of aeronautical engineers have had little regard for abstract ideas, preferring rather to pin their faith on practical cut-and-try methods of design.

The attitude of the present-day aeronautical engineer inclines him, very excusably, to base his work on previous designs or on wind tunnel tests. He has obscure notions about the air flow on which his design depends, but he can utilise certain empirical coefficients with more or less accuracy. When, however, he is asked to give an opinion upon some feature connected with the phenomena of flight he will, if the feature is a new one, be quite at sea. He is more handicapped, for instance, than the thermodynamical engineer, who can produce a fair design on paper even of an untried application of heat-engine principles. For example, no aeronautical engineer will, with confidence, offer a design for a flapping-wing machine, for he has at present no conception of the underlying principles that apply; he does not even know whether the same principles apply to a flapping-wing machine as to an aeroplane-type machine.

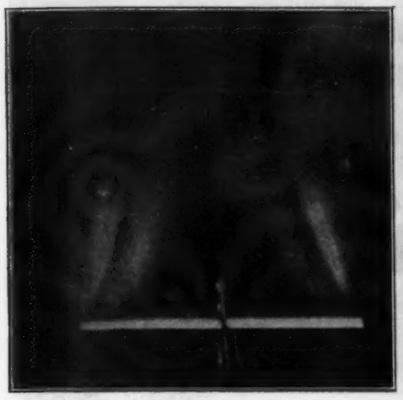


FIG. 1. VIEW OF TIP VORTICES LOOKING DOWN STREAM DIAGONALLY FROM ABOVE. BY LOOKING CLOSELY THE AXIS OF THE VORTEX AT THE RIGHT MAY BE TRACED.

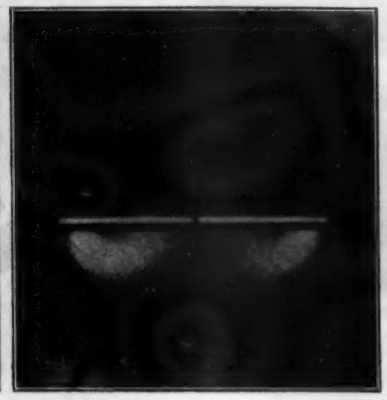


FIG. 2. VIEW OF TIP VORTICES LOOKING DOWN STREAM ALONG TUNNEL AXIS. THEY ARE EXPANDING CONES AND ARE HERE SEEN IN PERSPECTIVE.

When the proper physical basis has been determined for aeronautics, all problems will yield more readily to the designer's study. It is apparent that the science of aeronautics must eventually be brought to this stage, and that when that time arrives the entire mathematical theory of flight will constitute a powerful tool in the designer's hands. In the early period of any new art, there are always to be found idealists whose conceptions are ahead of the time; rational rather than practical. To these idealists comes ultimate recognition when ways and means of proof are discovered; usually their ideals excite only academic interest until suddenly a new application of science is discovered which fits the case. An example of such an idealist was Sir George Cayley, whose vindication was delayed until the invention of the Otto cycle engine.

As shown in this paper, the connecting link between abstract theory and practical engineering may soon be expected in the science of aeronautics. It has become possible to visualise the air flow, and, sixteen years after the accomplishment of manflight, to demonstrate empirically the physical laws underlying it.

Method of Air Flow Visualisation Developed by the Writers.—A method of visualising air flow has been discovered by the writers through the use of a wind tunnel of exceptionally high speed. The method utilises certain principles wherein moisture of the air is made to condense, becoming visible at the point of condensation. Analysis of air flow has heretofore been confined to the use of smoke or powder set loose in the air to indicate lines of flow; or of threads used as wind vanes. Or we have been driven to analogies derived from study of liquids of differing viscosity and density such as water. Or, further, we have sought by measurement of static pressures in the air surrounding a body to deduce the lines of flow. But these methods have not afforded quantitative measurement, nor adequate visualisation of flight vortices, and they have given small encouragement toward the practical application of aerodynamic theory to engineering use. Where foreign substances have been introduced into air to indicate the flow lines, the inertia of such substances has embarrassed the true determination of the line of flow. Water vapour, on the other hand, is one of the components of air, and when the vapour is made visible it is fair to say that the air itself becomes visible. In this method the true air flow is very closely approximated, and a photograph of the water vapour at the instant of condensation clearly shows characteristics which heretofore have been obscure in hydrodynamics. The photographs presented herewith show the vortices which have in the past been rationally

FIG. 3. SIDE VIEW OF WIND TUNNEL.

predicted, but not until now demonstrated. Fig. 1 is a photograph of the tip vortices behind an aerofoil, the focal axis making a vertical angle of about 30 deg. with the tunnel axis. In Fig. 2 the focal axis coincides with the tunnel axis. The apparatus used consists of a wind tunnel of such speed (675 ft. per second) that there is a fall of air density in the throat. It was designed by the writers, primarily to investigate the scaling effect applicable to use of laboratory coefficients in propeller design, inasmuch as there has been great need for data of this kind.

Scaling Effect.—The speed and size of a wind tunnel have recognised importance in the interpretation of all results obtained. The usual coefficients of aeronautical engineering are determined by tests on a model aerofoil of 3 in. to 6 in. chord, at velocities of 45 ft. to 100 ft. per second. The data obtained must be applied in the full scale to areas a hundredfold greater in the case of wings, and to velocities ten times greater in the case of propellers. There

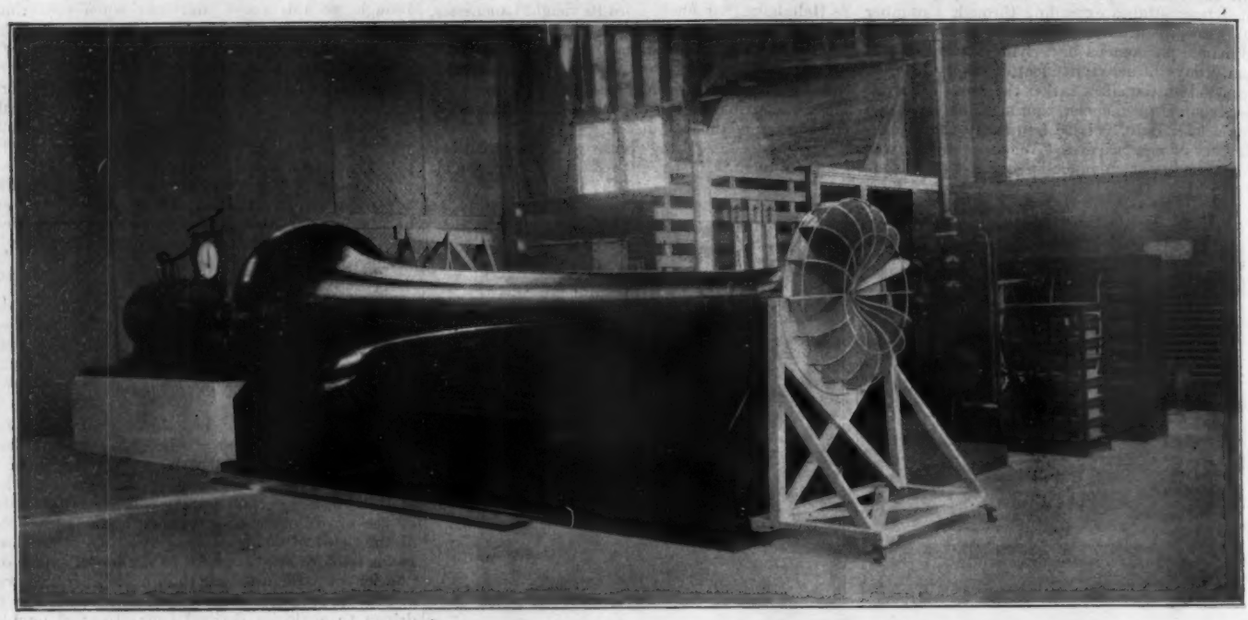


FIG. 4. THREE-QUARTERS VIEW OF WIND TUNNEL.

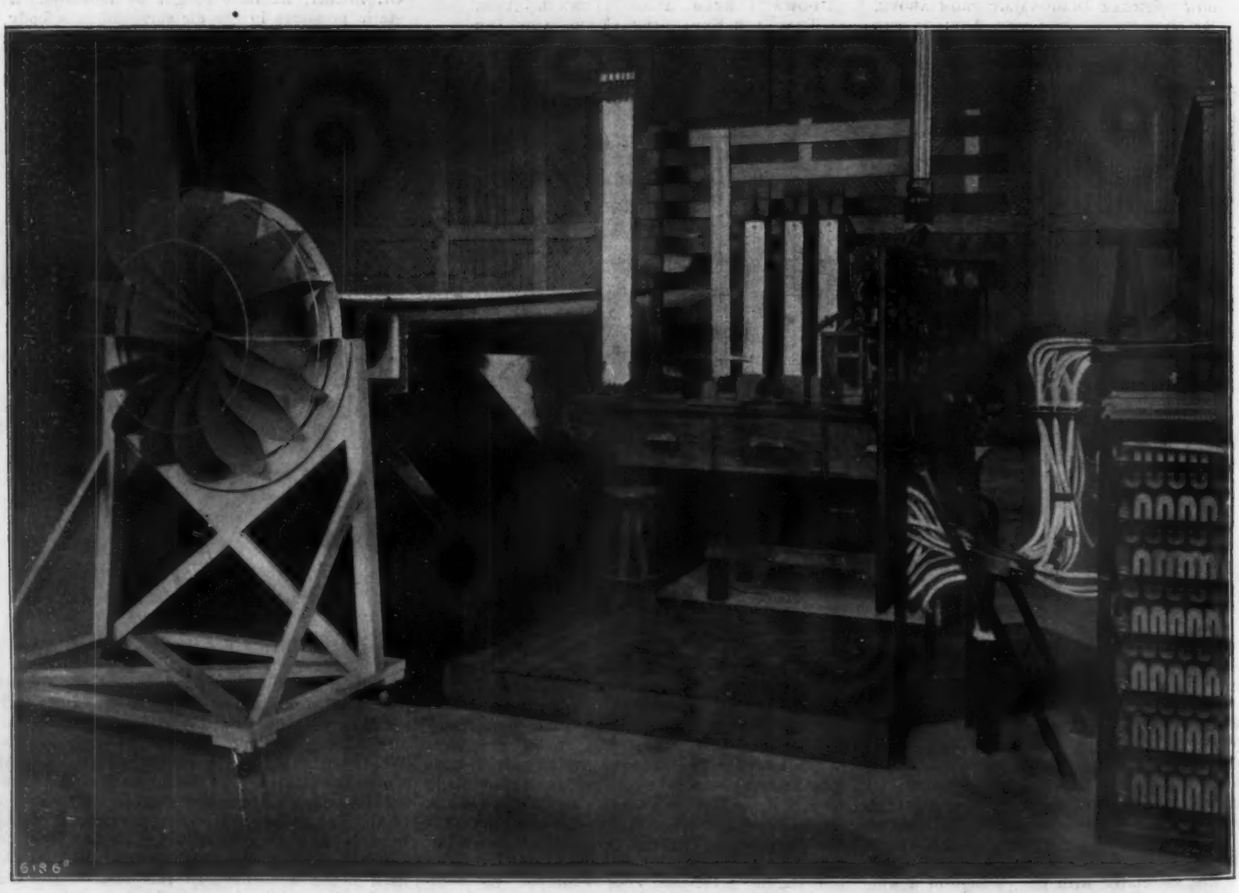


FIG. 5. VIEW OF WIND TUNNEL WITH AUXILIARY "STRAIGHTENER."

may be a discrepancy between model and full-scale coefficients. While scaling rules and empirical factors worked out in practice have enabled us to produce very fair results, there is decided room for improvement. Indeed, so meagre is the available information on the scaling effect, as treated under the "Law of Dynamic Similarity," that a growing tendency has appeared among aeronautical engineers to regard the classical coefficients K_x and K_y as inadequate. It has been almost universally the practice to write:

$$L = \frac{\rho}{g} K_y A V^2$$

$$D = \frac{\rho}{g} K_x A V^2$$

where L is the lift, D the drag, A the area of the supporting surface, V the velocity of advance, ρ the density of the air in weight units, g the acceleration due to gravity; hence ρ/g the density of the air in slugs. It is well known as the result of experience that the values of K_x and K_y vary somewhat with velocity, and also with the size of the surface under consideration. If l represents one of the linear dimensions of the surface and ν the coefficient of kinematic viscosity, it is assumed, according to the law of dynamic similarity, that values of K_x and K_y are functions of the product $\frac{V l}{\nu}$. The wind tunnel designed by the writers, permits the attainment of a $V l$ ratio of 60 (V in feet per second, l in feet). While this figure is 20 times less than the corresponding full-size wing values, it is only four to eight times less than full-size propeller values. The studies afforded have greater significance than if the same ratio were obtained with a larger model and smaller velocities. Two discoveries of outstanding importance have been made in this tunnel, as described hereafter; they are, the visualisation of flight vortices, and the identification of changes in these vortices with changes of the aerofoil coefficients.

Description of the Wind Tunnel.—As in other wind tunnels, air is sucked through a horizontal tube, in which it blows against a small model at known velocity. The model is supported by a rod projecting from a suitable balance into the tunnel, and the forces concerned in flight can thus be measured. The air, after passing the model, is decelerated in an expanding cone and exhausted into the room by a propeller fan. Description of the tunnel need include only those features which differ from the standard type. The intake trumpet, tube and expanding cone, have the general form of a Venturi tube with length 18⅔ ft.; intake trumpet diameter, 3½ ft.; radius of curvature 22¾ in.; throat diameter, 14 in.; fan diameter, 5 ft. The cone walls make an angle of 5 deg. for the first 100 in. (See Figs. 3 and 4.) The usual honeycomb is omitted, but a four-bladed "straightener," 48 in. long, is inserted in the cone 4 ft. down-stream from the model, at which point it is effective in forestalling entrance whirl. This straightener cuts down the fluctuations of velocity from 15 per cent. to 3 per cent. As shown in Fig. 5, there is an auxiliary straightener, outside the intake bell, having flat radial vanes. These straighteners do not materially reduce the wind-tunnel efficiency. Fig. 6 shows the result of a test made to delimit the function of the conventional honeycomb, which, in this wind tunnel, is omitted. It is seen that good velocity traverse does not necessarily depend on the honeycomb; this test is one of an extensive series made on model wind tunnels to determine various design problems. The type of intake and straightener used in the McCook-Field wind tunnel, and the location of the model near the intake, are those recommended as the result of these model tests.

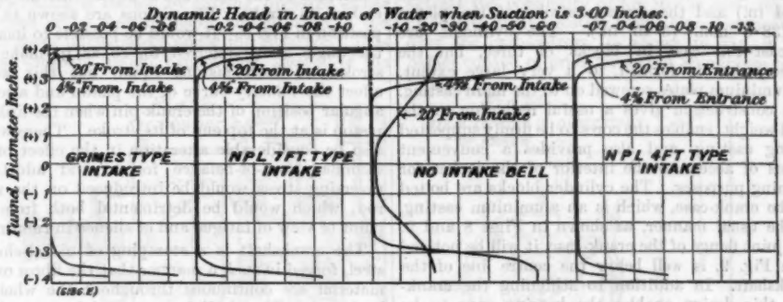
The power plant consists of a Sprague dynamometer, capable of delivering 200 h.p. for ½ hour, at 250 volts and 1,770 r.p.m., without overheating. The 5-ft. fan is made with a solid centre disc, 40 in. diameter, and has 24 blades, 10 in. long (Fig. 7). At the up-stream side of the 40-in. disc, a bell of equal diameter is fixed in the tunnel so that the air is led up to the annular discharge opening with a minimum of eddies; the operating efficiency of the whole tunnel is 76 per cent. higher than has been usual for determination of aerofoil coefficients in other wind tunnels. By efficiency is understood the ratio of kinetic energy of airstream at throat of tunnel, minus the energy absorbed by the fan, all divided by the energy of the airstream at the throat.

Careful study of fan and cone design results not only in reduced losses, but also in reduced noise. The question of noise has, in the past, been a serious objection to speeds greater than 70 m.p.h. in wind tunnels. The roar of the fan is analagous to that of an aeroplane propeller, which usually makes more noise than does the unmuffled motor exhaust. For wind tunnel use the combination of fan and cone adopted has brought about a considerable improvement as indicated in the following tabulation:—

	M.P.H.
From the operator's position—	
The fan is noiseless	50
Starts to roar	60
Conversation easy	125
Conversation slightly forced	155
,, possible 12 in. apart ...	240
,, possible 4 in. apart ...	300

Balances.—The balances are of two types. The first one measures lift and drag on two separate instantaneous reading Toledo scales. It is mounted upon a portable carriage (see Fig. 8). The spindle for the model projects horizontally and axially from this carriage into the mouth of the wind tunnel, carrying the model at its free end. The spindle terminates in a thin flat bar, the latter clamping a graduated disc, which is rigid with the model at the

Fig. 6. DYNAMIC HEADS IN MODEL WIND TUNNEL FLUE FOR COMPARING VELOCITY TRAVERSES OF DIFFERENT INTAKES
Suction from Vacuum Chamber; No Honeycomb used; No Cone Used.



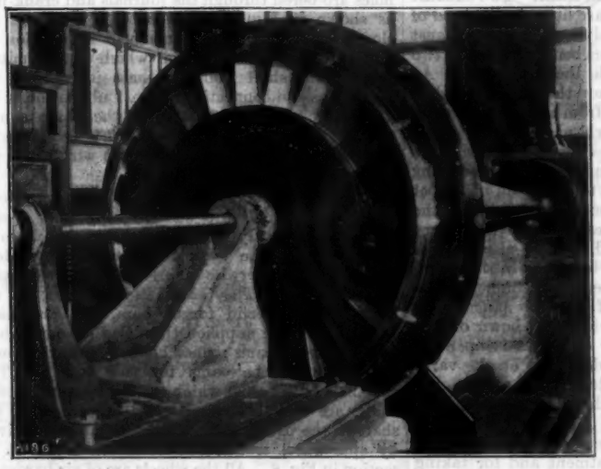


FIG. 7. WIND TUNNEL FAN.

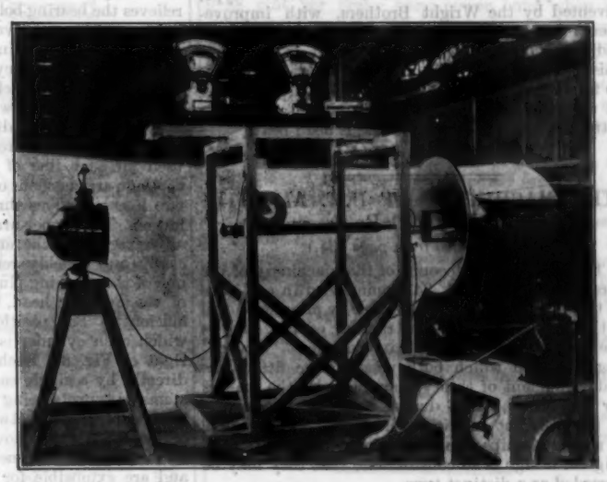
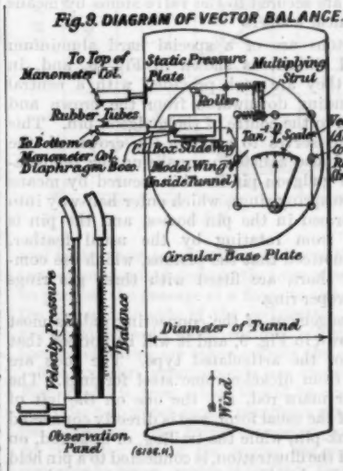


FIG. 8. WIND TUNNEL BALANCE CARRIAGE.

Fig. 9. DIAGRAM OF VECTOR BALANCE.



centre of the span. Three advantages of this type of balance are, first, that instantaneous readings make it possible to synchronise balance and velocity observations and practically to eliminate the effect of velocity fluctuations. Second: The air forces can be qualitatively studied; as, for instance, in the case where a given set-up has two values of K_y. The balance can then be seen to change from one reading to another. Third: The method of support affords a highly accurate means of skin friction observation.

The one-end spindle used at the National Physical Laboratory cannot be utilised under the conditions of these tests. In order definitely to delimit the effect of the supporting member, further developments are proposed where this effect will be virtually eliminated from the tests. The effect of the centre support on the lift coefficient is not considered serious. This conclusion is based on experiments run at other laboratories where the effect of the support has been determined; also on a comparison of the present series of experiments with tests made elsewhere on a larger model, supported at the end, for the same $\sqrt{V}L$ values. The effect on the centre support on drag, however, is known to be large. The air flow disturbance is visualised in Fig. 11 (to be given later on), where it appears as a white tuft above the support. The second type of balance is of the "Vector" type, invented by the Wright Brothers, with improvements developed by the writers. The principle is indicated on the sketch Fig. 9. It is seen that this balance reads L/D with an accuracy superior to the ordinary type, and that it reads lift and drag in terms of static pressure. The advantage of the latter feature is that the reading is dead-beat.

(To be continued.)

THE MACHINERY OF H.M. AIRSHIPS R. 33 AND R. 34.

(Concluded from page 434.)

To conclude the account of the machinery of the airships R. 33 and R. 34, commenced in our issue of the 2nd inst., on page 433, we now propose to deal with the design and construction of the engines themselves. The Sunbeam-Coatalen "Maori" engines, with which both vessels were fitted, are a development of the type supplied by the makers for use on seaplanes during the war, but, owing to the different conditions under which they have to run on airships, the amount of deviation from the original design is so considerable that they may be regarded as a distinct type.

One of the features affecting the design was the fact that, in an airship, it is easily possible to make adjustments, and even small repairs, during the course of a flight, which, of course, cannot be done on a seaplane. Again, the presence of a clutch referred to in our first article, enabling the engine to run completely disconnected from the propeller, necessitated the provision of a controlling device which took the form of a centrifugal governor. Fuel economy is also of the utmost importance in an airship engine, which is called upon to run for very long periods, the saving of a small fraction of a pound in the consumption per brake horse-power hour more than compensating for a very considerable increase in the weight of the engine. Further, the engine must run economically for long periods at any speed from the maximum to the minimum, and consequently special provision had to be made to ensure the maintenance of the correct temperature of the oil and cooling water, since the speed of the air past the radiators is not proportional to the power output of any particular engine as it is in the case of an aeroplane or seaplane. We called attention to the arrangements made to expose a greater or lesser proportion of the surface of the cooling water radiator in our previous article.

After these few preliminary remarks we may proceed to describe the construction of the engines in detail with the aid of the drawings and photographs reproduced on Plate XXVII. The left-hand portion of Fig. 8 is a longitudinal vertical section on the centre line of the engine, while the right-hand portion is a section through a group of cylinders which are inclined at 30 deg. to the vertical as shown in the transverse section, Fig. 9. The appearance of the engine is well shown by the three half-tone illustrations, Figs. 10, 11 and 12, which are, respectively, a view of the forward end, a side view, and a view of the after end. As previously stated, there are five engines, all exactly similar, in each of the airships, each engine giving 270 brake horse-power at 2,100 r.p.m., so that the total power of each airship amounts to 1,350 brake horse-power.

The engines are of the twelve-cylinder type, two rows, of six cylinders each, being arranged in the form of a "V" with an angle of 60 deg. between them. The bore of the cylinders is 100 mm. (3·94 in.) and the average stroke of the piston is 138·5 mm. (5·45 in.). The cylinders are of cast-iron cast in blocks of three, but the water jacket is formed, to a very large extent, of aluminium plates screwed on to the main casting. This construction gives a useful reduction in the total weight, enables the cores to be firmly supported during casting, and also provides a convenient means of access to the interior of the jacket for cleaning purposes. The cylinder blocks are bolted to the crank-case, which is an aluminium casting, in the usual manner, as shown in Figs. 8 and 9. The joint flange of the crank-case, it will be noticed from Fig. 9, is well below the centre line of the crankshaft. In addition to stiffening the crank-case this design enables the bearing caps to be accurately fitted between two cheeks, and thus relieves the bearing bolts of all shear. Two exhaust valves and two inlet valves are fitted in the head of each cylinder, all the inlet valves and all the exhaust valves for each row of cylinders being arranged in two separate lines parallel with the crankshaft. An inspection of Fig. 9 will show that the method of operating the valves differs from that more usually employed, a separate overhead camshaft being used for each line of valves instead of the more common arrangement of a single camshaft operating two lines of valves through the medium of tappet levers. The former arrangement, however, has the advantage that the entire cam gear can be very easily and quickly removed, and it also enables one of the sparking plugs to be placed in the centre of the cylinder head, thus ensuring high ignition efficiency. The positions of the two plugs, with which each cylinder is provided, is shown on the right of Fig. 8. Each pair of valves is operated directly by a single cam, side thrust on the valve stems or tappets being avoided by the provision of fingers interposed between the cams and the ends of the tappets, as shown in Fig. 9. The tappets, it should be mentioned, are made in two parts, and are extensible for adjustment and for taking up wear. The valves are of the tulip form, and they are fitted with double helical springs, the washers for which are secured to the valve stems by means of split conical washers.

The pistons are of a special hard aluminium alloy, well ribbed, as shown in Fig. 9, and, in addition, they are each provided with a central stem extending downwards from the crown and bedding on to the centre of the gudgeon pin. This arrangement serves to support the crown of the piston, and also assists in equalising the temperature. The gudgeon pin itself is secured by means of two wire spring rings, which enter half-way into grooves formed in the pin bosses, and the pin is prevented from rotating by the usual feather. It will be noticed that the pistons, which are comparatively short, are fitted with three gas rings and one scraper ring.

The arrangement of the connecting rods is most clearly shown in Fig. 9, and it will be noticed that they are of the articulated type. The rods are machined from nickel-chrome steel forgings. The leading, or main rod, *i.e.*, the one on the left of Fig. 9, is of the usual form, and is directly connected to the crank-pin, while the trailing, or link, rod, on the right of the illustration, is connected to a pin held in a fork formed on the main rod. This fork is shown under the third cylinder from the flywheel end in Fig. 8. This arrangement has a considerable advantage over that more usually adopted in the case of two connecting rods working on the same crank-pin, in that one of the rods may be replaced without having to bed a second rod on to the back of it. In extreme cases, with the usual arrangement, it may be necessary to replace one damaged rod by two new ones, both of which would have to be bedded. The effect of the construction illustrated in Fig. 9, is that the length of the stroke of the piston connected to the link rod depends upon the angle between the axis of the main rod and the ears of the fork to which the link rod is connected. The angle chosen by the makers for this detail, is such as to give a slightly longer stroke to the link-rod piston, but, at the same time, it allows both centres of the link rod and the crank-pin centre to be in line at the correct angle of rotation, *i.e.*, when the piston connected to the main rod is at the extreme upper end of its stroke. The pistons are shown in this position in Fig. 9. It would be possible to increase the angle above referred to, so as to make the strokes of both pistons equal, but this would affect the velocity curve of the piston and also the angular position of the crank-pin when the link-rod piston is at the top end of its stroke. There would also be considerable alteration in the effect of the secondary out-of-balance forces, and additional reversing stress would be introduced on the main rod, which would be detrimental both from the point of view of fatigue and of silence in running.

The crankshaft is a stamping of nickel-chrome steel, forged in such a manner that the fibres of the material are continuous throughout the whole of its length. The shaft is supported in seven large bearings, lined with white metal, and large lightening holes are bored through the journals and crank-pins as shown in Fig. 8. The ends of the holes are closed by light steel washers held in position by bolts so as to retain the oil which is transmitted through the shaft from the main journals to the crank-pins and connecting rods. Lubrication of the link-rod pin is supplied from the same source through ducts connecting the main big-end bearing with the hollow pin and bronze bush with which the link rod is fitted.

The camshafts are housed in casings of cast aluminium, which are self aligning and give a support sufficiently flexible to take up any movement between the adjacent groups of cylinders, which might otherwise interfere with the bearing of the shaft. The camshafts themselves are machined from solid forged bars, and are made hollow, oil being supplied through the central hole to lubricate the cams; small holes are drilled through the backs of the cams for this purpose. The camshaft bearings, of which there are seven for each shaft, are also lubricated from the centres of the shaft in the usual way. The camshafts are driven by spur-wheel trains, one of which is shown in section in Fig. 8. All the wheels are of air-hardened nickel-chrome steel and run on ball bearings, as shown. Various auxiliaries, including the magnetos, revolution counter, air pumps, &c., are driven from the gear train by easily detachable couplings. The wheel covers, which are distinct from the cylinder castings, can be removed separately, and the auxiliaries can also be removed without interfering with the timing wheels or any other parts of the engine. The housing of the camshaft drive wheels also houses the governor gear, which is arranged to cut off the ignition when the speed of the engine reaches 2,500 r.p.m., and also when the oil pressure falls below the minimum allowable value, viz., 25 lb. per square inch. Details of the governor gear are illustrated in Figs. 13 to 16, on page 505, and its position is shown on the right of Fig. 8, just below the magneto. The governor is of the centrifugal type, its action being controlled by the spring shown in Fig. 13, which is adjusted and sealed at the maker's works. Movement of the governor arms rocks a horizontal tubular shaft through the medium of a short forked lever, and this shaft operates a cut-out in the ignition system as will be clear from an inspection of the figures. The device for protecting the engine against failure of the oil pressure is shown in Fig. 15, and consists of a small cylinder containing a piston, the left-hand side of which is acted upon by the oil pressure. Under normal working conditions the piston is held outwards against the action of a spring shown in the upper part of the figure, the trigger which passes through an opening in the cylinder wall then being in contact with the periphery of the piston. A failure of the oil pressure, however, will allow the piston to be drawn back by the spring so that the

trigger moves into the position shown in the illustration. In this position the lower spring tends to turn the tubular shaft in the opposite direction to the main governor spring, partially neutralising the latter, and thus allowing the governor to act at a much slower speed than the normal, viz., 300 r.p.m.; a split sleeve on the shaft, shown in Fig. 16, prevents the pressure of the lower spring from coming on to the shaft in normal working, and, in starting up, it is held back by a small hand plunger, which is released when the engine is running.

The engine is started by gearing, operated either by hand or by electric motor and situated in the front cover immediately under the governor. It is of the ordinary design, except that, instead of the usual rachet for over-running, the "throw out" on starting is obtained by a gear wheel with spiral teeth incorporated in the mechanism. Compressed air starters, similar to those employed in Sunbeam aeroplane engines, were fitted when the engines were originally installed, but these were found to be unnecessary and were subsequently removed.

Fig.13.
SECTION ON C.D.

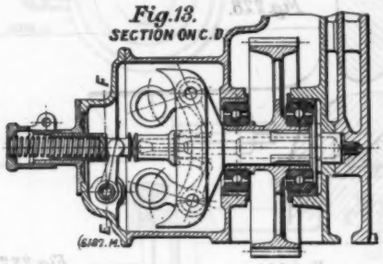


Fig.14
VIEW LOOKING IN DIRECTION OF ARROW.

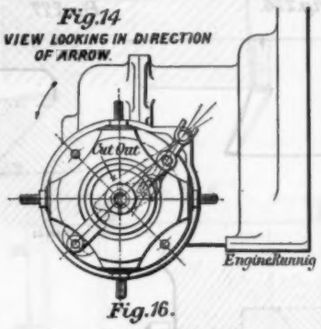


Fig.15.
SECTION ON A.B.

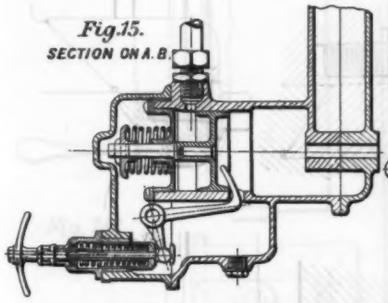
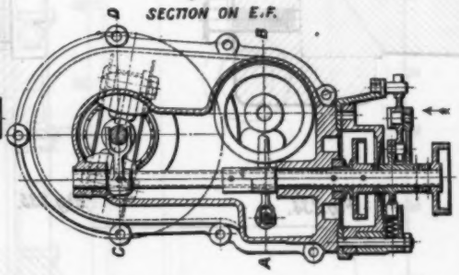


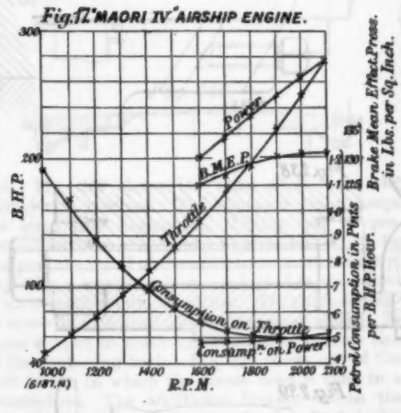
Fig.16.
SECTION ON E.F.



In connection with the lubrication system of the engine, four pumps are provided, all of which are of the gear wheel type and are driven from the crankshaft by skew gearing. Of these, the main suction pump, shown in section at the right-hand bottom corner of Fig. 8, draws the used oil from the crankcase and returns it to the tank, while an auxiliary suction pump is used to collect the oil from the cam sleeves and other parts in which it would otherwise accumulate. The main pressure pump draws oil from the tank and supplies it, at a pressure of 45 lb. per square inch, to the crankshaft for lubricating the main bearings and big ends of the connecting rods, as previously explained. An auxiliary pressure pump is used to supply oil at a lower pressure to the camshafts, &c. The filtering of the oil is obviously a matter of considerable importance in an engine which is required to run for very long periods without stopping. In the engine we are describing, filters are provided on both the pressure and suction sides of the main pressure pump, and the filters are duplicated so that one-half of either can be taken down for cleaning while the other half is in use. The quantity of oil circulated is very large, and the circulation system includes an oil cooler fixed on the outside of the car in order to dissipate the heat generated. These oil coolers were referred to in our previous article, and they are shown in Fig. 1, on Plate XXV, which accompanied our issue of the 2nd inst. The oil connections are arranged so that the coolers can be cut off more or less in order to regulate the temperature, and the oil supply can be replenished while the engine is working, through pipes connected with the main tank in the body of the ship. Provision is also made for warming the main tank to prevent the oil from becoming solid at the very low temperatures experienced at high altitudes.

Four carburettors, of the Claudel-Hobson B.Z. type, are fitted to each engine, each carburettor supplying a group of three cylinders, as will be clear from the half-tone illustrations, Figs. 10 to 12, on Plate XXVII. The carburettors are fitted with a device to compensate for the changes in density of the air at different altitudes. The inlet pipes are provided with hot-water jackets, and to guard against the possibility of fire in the cars, they are fitted with flame-resisting baffles placed immediately over the carburettors, as shown in Fig. 9. The baffles consist of grids formed of aluminium plates,

Fig.17."MAORI IV" AIRSHIP ENGINE.



and their effect is, of course, to lower the temperature of any ignited gases in the inlet pipe sufficiently to prevent the passage of a flame to the carburettor. On the suction side of the carburettor, the intakes are provided with gauze-covered mouthpieces, and the petrol drains are taken outside the car.

The exhaust arrangements are clearly shown in Figs. 8 and 9, from which it will be seen that they comprise two water-cooled manifolds placed between the cylinders, one being connected to each row. At the after end of the engine the manifolds are connected by a water-jacketted breeches pipe, shown in Fig. 12, to a transverse pipe section which leads the gases to the external exhaust pipe, as clearly shown in Fig. 1, on Plate XXV in our previous article. The whole of the cooling water for the engine is circulated by a single large pump of the centrifugal type, driven directly from the engine crankshaft and shown in section in Fig. 8. The control valves in the pipes are provided for use when the ship is in the shed, connection then being made to an electric water heater which keeps hot water in circulation and thus avoids the necessity for draining the jackets in cold weather. The levers for regulating the ignition, and the throttle and atmospheric controls, are grouped together on a small instrument board mounted on the forward end of each engine, as is most clearly shown in the interior view of the after car of R. 33, reproduced in Fig. 5 of Plate XXV. With this arrangement the minimum possible number of connections have to be made or broken when replacing or removing an engine. As mentioned in our previous article, each engine is fitted with a flywheel of sufficient weight to enable it to run when disconnected from the propeller. The flywheel is shown in Fig. 12, and the driving ring, which is recessed to take the blocks of resilient material for transmitting the drive to the gearing, will be noticed.

The total petrol consumption of the five engines in a ship is given as 71·5 gallons per hour with full load near the ground, the consumption falling to 59·5 gallons per hour at 5,000 ft. At cruising load the consumption near the ground is 47 gallons per hour, while at 5,000 ft. the corresponding consumption is 39·5 gallons per hour. In Fig. 17, annexed, we give the results of a bench test on one of the engines, and from this diagram it will be seen that the petrol consumption ranges from about 0·48 pint per brake horse-power hour when the engine is running at 1,600 r.p.m. and giving 200 brake horse-power, to about 0·52 pint per brake horse-power hour at full speed when the output is about 275 brake horse-power. The brake mean effective pressure is also given for this range of speeds, and the consumption on the throttle is given for all speeds from 1,000 r.p.m. to 2,100 r.p.m. To obtain the throttle curve, it may be explained, the engine was opened out to full power and sufficient load applied to give the maximum speed of 2,100 r.p.m. This load was maintained and the throttle gradually closed, giving the results shown in the diagram, the curve marked "consumption-on-throttle" giving the petrol comsumption during this operation. The power curve was obtained with the throttle fully open during the whole of the test, the load on the brake being gradually increased so as to reduce the speed as shown.

In conclusion we must express our indebtedness to the Sunbeam Motor Car Company, Limited, for the drawings and information placed at our disposal to enable the engravings and descriptive matter to be prepared.

RECENT MACHINE TOOL DEVELOPMENTS. XI.

By JOSEPH HORNER.

Adjusting Strips, and Lubrication of Slides.—When fitting adjusting strips they cannot be regarded alone without the consideration of other matters of consequence. Bearing surface is one. It is obvious that when much pressure comes on one portion of a slide, great assistance can be derived by the inclusion of a broad bearing surface adjacent to the vee edge or edges. This is why many machine tables with vee'd guiding edges have broad, flat bearing surfaces extending out beyond the edges. In some cases one edge only need have this additional support. The top slide of an ordinary lathe tool rest is a case in point. The stress transmitted through the cutting tool is very severe, and comes on and about the extreme edge. The value of a broad bearing surface there is apparent. But at the back there is no such pressure, but only a powerful tendency to lift the upper off the lower slide. A broad bearing therefore is useless. The vee'd edge, or the square edge alone, requires to be gibbed in opposition to the force tending to tilt.

In practically all slides provision has to be made for taking up wear. The same necessity exists in rotating spindles, but the conditions that control the two differ. In each there are very many variations. In each there have been developments that promise to be reasonably permanent. In the slides the longitudinally tapered strip is becoming rather common. But there is no one design that is suitable for all condition and positions. Convenience must be considered as well as efficiency, location, simplicity and ease of adjustment, com-

RECENT MACHINE TOOL DEVELOPMENTS.

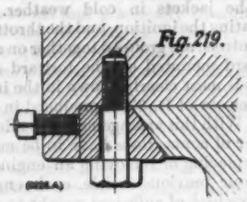


Fig. 219.

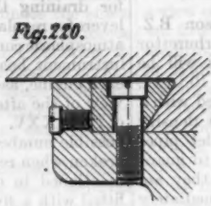


Fig. 220.

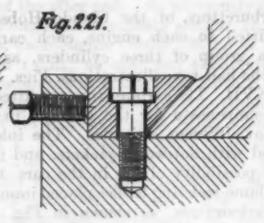


Fig. 221.

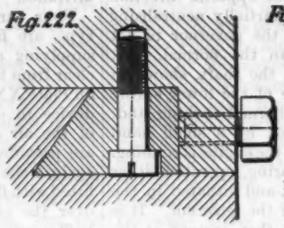


Fig. 222.

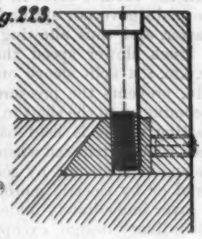


Fig. 223.

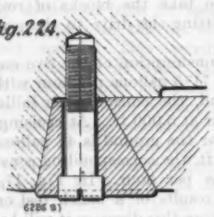


Fig. 224.

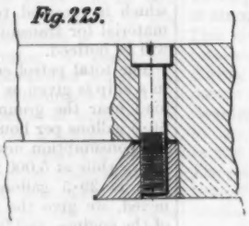


Fig. 225.

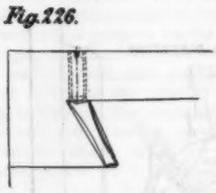


Fig. 226.

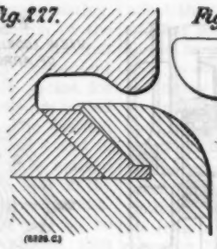


Fig. 227.

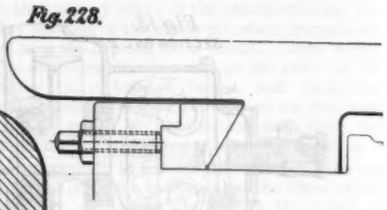


Fig. 228.

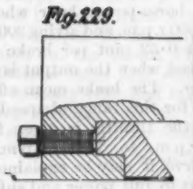


Fig. 229.

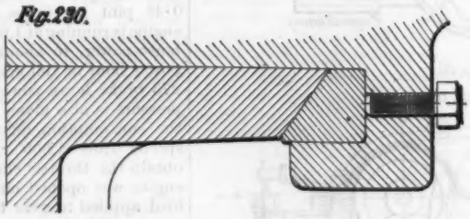


Fig. 230.

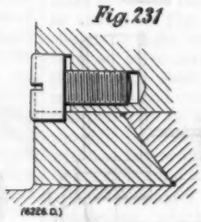


Fig. 231.

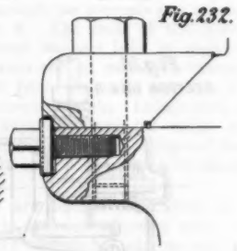


Fig. 232.

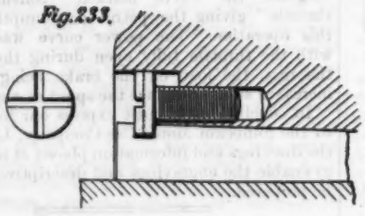


Fig. 233.

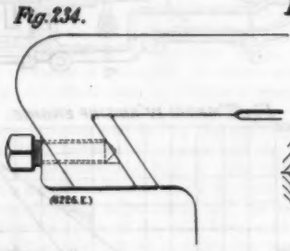


Fig. 234.

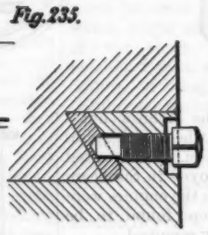


Fig. 235.

Fig. 236.

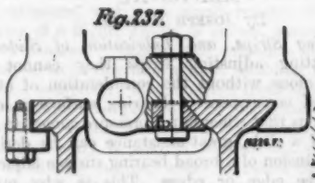


Fig. 237.

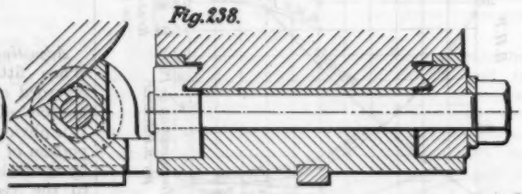


Fig. 238.

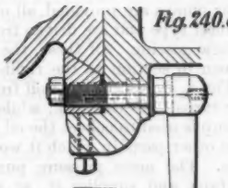


Fig. 240.a.

pactness, sureness, the avoiding of awkwardly-projecting parts, and so on.

The primary object of a strip is to secure a close-sliding fit between parts and, because slides wear, to do what a solid fitting could not do—compensate for wear. In general lateral movement alone need be dealt with, but in a good many instances a lifting or tilting action has also to be guarded against. When this occurs the vee'd edge slide often fulfils both functions. But in many cases it does not. Neither does the square edge. All strips and their abutment slides must be rigid enough to resist spring when the setting-up screws are tightened.

Again, there are instances in which the forms of the ways provide for take-up. This is the case in the lathe beds with vee'd ways, and in the ordinary planing machine beds. But lifting has to be provided against with flat strips underneath an edge. A grinder table running on vees neither requires lateral take-up, nor provision against lifting. A heavy planer table on vees is similarly circumstanced, but lifting may have to be provided against in the case of light tables.

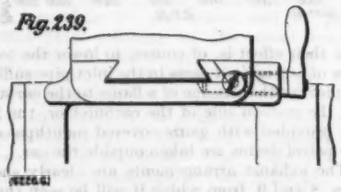


Fig. 239.

Strips with Bevelled Edges.—The common form of strip, the one most often met with, is shown by Fig. 219, but it is subjected to various slight modifications. The horizontal set-screw imparts the lateral pressure, which would jamb the strip against the edge but for the tightening of it up against the horizontal face of the slide. The slot hole provides the maximum clearance allowance for taking-up. The opposite edge of the slide may be a vee, or square. If the latter, a flat strip is necessary to prevent lifting on that edge. In Fig. 220 the vee is situated the reverse way, the example being from

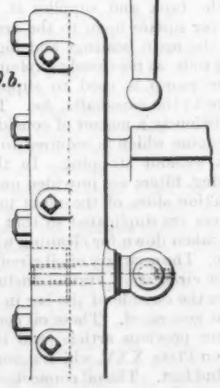
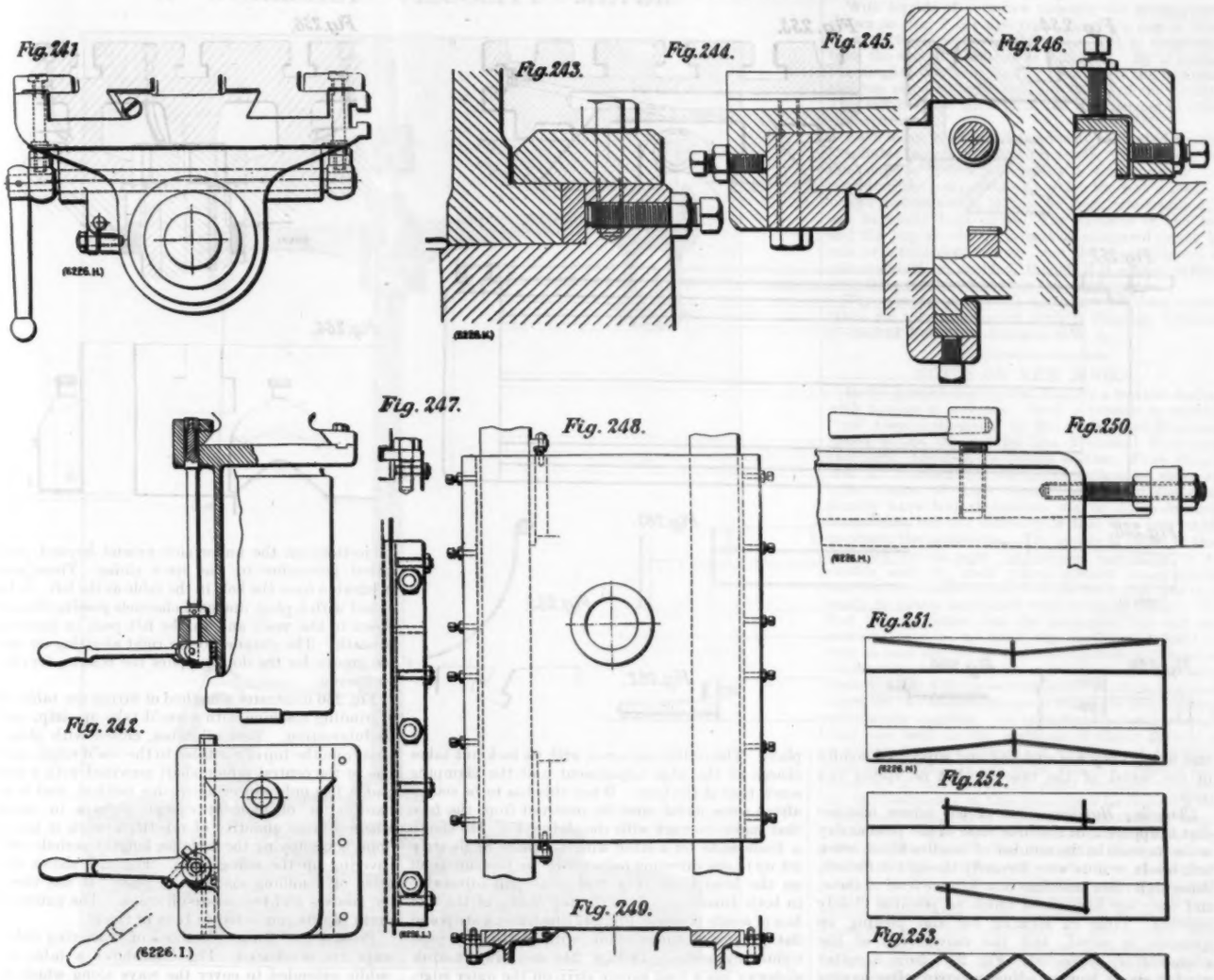


Fig. 240.b.

the table of a milling machine in which the vee is covered and protected by the sliding table. This entails the sinking in of the head of the screw flush with the face of the strip. Otherwise the action is

RECENT MACHINE TOOL DEVELOPMENTS.



identical with that in the previous Fig. 219. The setting-up screw is sunk in nearly flush, which may be preferable to allowing the head to stand out as in Fig. 219. An alternative is shown in Fig. 221, suitable for use whether the strip is either covered or exposed. The head of the set screw is sunk in and is turned with a box spanner, which is preferable to a slotted screw head like that in Fig. 220 for heavy slides. Alternatively the head may fill the arbored hole, and be recessed square to receive a square wrench. Fig. 222 is not a very good design, not being convenient because it has to be adjusted from below. But it is used on some slide rests. Fig. 223 is better, because the screw is more readily tightened from the top of the slide.

Figs. 224 to 226 illustrate the utilisation of wedge action to avoid the employment of setting-up screws, the pulling-down screws fulfilling also that function. In Fig. 224 the slope at the back has the effect of setting-up when the screws are tightened. It is necessary to have a clearance in the plane face of the strip as shown. In Fig. 225 the effect is the same with a square edge opposite to the slope. Fig. 226 shows a common practice where grub screws force the wedge strip downwards.

Fig. 227 illustrates a longitudinally tapered gib which is prevented from lifting by the tongue seen that fits into the slideway. If the under face of the table moves on the face of the slideway, as it does in some cases, the tongue would not be required. Another non-lifting shape is shown in Fig. 228, where a shoulder going along the strip prevents it from lifting. The setting-up screw has a locking nut. Fig. 229 shows the same effect, only the shoulder is reversed. The clearance below keeps the strip from tightening. Lifting can be prevented without employing a projecting strip by carrying the metal of the slide underneath the strip, Fig. 230, a method which is adopted in the tables of some small planing machines. The single setting-in screw is sufficiently secure for small slides. In those subject to much vibration there is some risk of its slackening back. Fig. 231 shows one of the best forms, in which the cheese head is sunk in a counterbore. The additional friction lessens the risk of movement, and protection is afforded also to the head. A single screw suffices here, because the gib takes a bearing on both its upper and lower faces. Fig. 232, from the saddle of a shaping machine, shows a setting-in screw turned in with a spanner. It has a collar that bears against a recess in the gib similarly to Fig. 231, this collar fitting into an arbored recess. Here a clamping screw is necessary to hold and tighten the gib. In Fig. 233 another application of a filister head screw is shown in which the head fits in a recess, and moves with a gib tapered longitudinally. There is no companion screw at the opposite end, so the screw head is made to move and ease the strip in both directions. This is sunk in because a similar companion saddle comes next its face. The slots in the screwhead at right angles permit of making minute movements in a restricted space.

Strips of Parallel Thickness.—Bevelled edges need not necessarily have take-up strips of the regulation form with square outer edges. For light slides very many are fitted as in Figs. 234 to 236, with strips of parallel thickness. In Fig. 234 the points of the setting screws are relied on to keep the gib in position. In Fig. 235 the strip is further secured by being enclosed between the bed and table. In Fig. 236 the setting screws are disposed at right angles with the face of the gib, which is better when the arrangement is possible. Another security here is the fitting of a lock nut.

Combined Gibs and Clamps.—Gibs often fulfil another function besides that of adjustments, and take-up for wear. They are made the means of clamping in addition. The inverted vee in some lathe beds is a case in point. It ensures that the poppet is always pulled up against one edge to maintain its alignment. In Fig. 237 the head of a gear cutter is guided by one slideway—a narrow guide. The strip is pulled up and tightened with a bolt, a slight clearance being left between the face of the strip and the bottom of the head, and the bolt is prevented from turning by a pin. The other slideway has clearance along the edge and a flat gib prevents lifting. Fig. 238 shows how a cylindrical body, that of the dividing head of a milling machine, is clamped on its annular vee'd edges in perfect balance. The clamping blocks on opposite sides are pulled together simultaneously by the through-bolt

RECENT MACHINE TOOL DEVELOPMENTS.

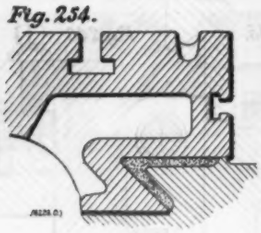


Fig. 254.

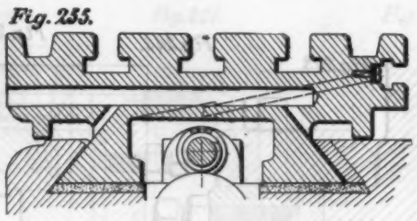


Fig. 255.

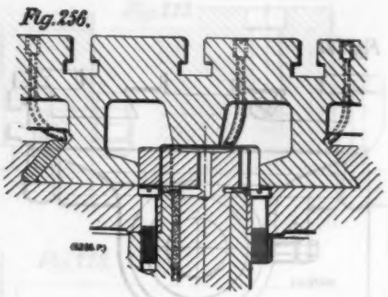


Fig. 256.

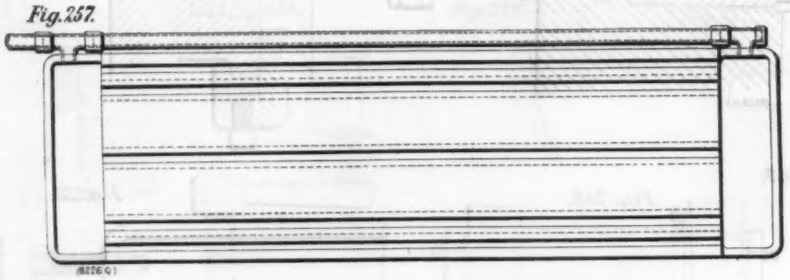


Fig. 257.

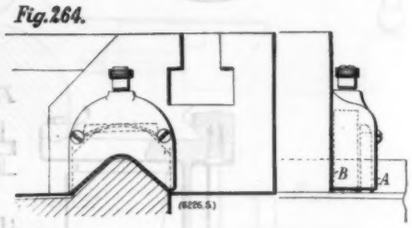


Fig. 264.

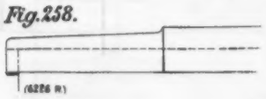


Fig. 258.

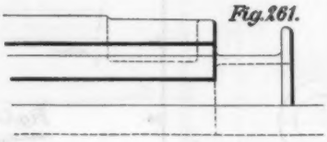


Fig. 261.

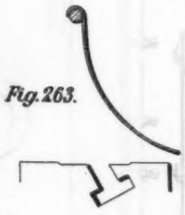


Fig. 263.

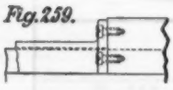


Fig. 259.

Fig. 260.

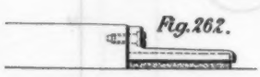


Fig. 262.

and nut. They are enclosed and supported solidly in the metal of the base so that no spring can occur.

Clamping Handles.—One of the minor features that is apparent in machine tools of the present day is the increase in the number of handles fitted, when bolt heads or nuts were formerly thought sufficient. Some high-class machines now have several of these, and they are located as much as possible closely together. Time in hunting for and picking up spanners is saved, and the movements of the attendant are restricted. Fig. 239, from a cutter grinder, shows how an adjusting strip, after having been set up by the filister head screw, is clamped by the pad notched to fit the strip and thrust by the screw handle. In the majority of instances of this kind handles are fitted. Figs. 240*a* and 240*b* show the slide of a milling machine clamped with a screw entering a bevelled block and pulling it tightly, a handle being used for the purpose.

Fig. 241 shows a double clamp applied to the head of a vertical milling machine. The clamping is effected by moving the rod (which is actuated by the handle), with slightly eccentric ends. These are encircled by freely fitting bossed lugs that receive the screws of the clamp bolts which pull the clamping plates up behind the square ways. Nuts, and lock nuts adjust the depth of the screws in the bossed lugs. The take-up of the slide is effected by the vee guides on the inner edges of the flat ways, a taper strip and filister headed screw being employed for the purpose. The gibs on the outer square edges provide stability to the broad flat sliding surfaces beyond the vee'd edges. Fig. 242 shows a clamp fitting for the knee of a milling machine which sets down the whole length of bearing surface. Turning the handle from the full line to the dotted position moves the small pinion and forces the tapered strip along.

Square Gibbing.—Square gibs are secured similarly to those of vee'd section. Fig. 243 shows one applied to the ram of a shaping machine. It is set up with side screws having lock nuts, and it and the ram are kept from lifting by the covering plate above. Fig. 244 is a combination strip for a square edge fulfilling the function of a gib and a covering plate. The setting-up screw with its lock nut takes charge of the edge adjustment and the clamping screw that of the face. When this has to be set up afresh some metal must be removed from the face that makes contact with the slide. Fig. 245 shows a front slide for a lathe with a square angle strip set up in one direction only where the pressure is all on the front face. Fig. 246 is a strip adjustable in both directions. It is the top fitting of the tool box of a side planer. Fig. 247 illustrates a strip and flat gib for a turret slide with setting-up and tightening screws. In Figs. 248 and 249 a narrow slideway has a long square strip on the outer edge, and two tapered gibs with longitudinal adjustments for effecting a close fit. The opposite side has a square edge with clearance and a flat gib. Fig. 250 shows a tapered gib with its lug and setting up screw, and in addition a clamping screw with handle.

Lubrication of Slides.—Methods of lubricating slides are shown in succeeding figures. Shallow grooves distribute oil over surfaces similar to those employed in journal bearings. These are variously disposed. In Fig. 251 the grooves receive the oil through the central oiling holes and distribute it across the bearing width to right and left. In Fig. 252 the grooves distribute it transversely and diagonally. One of the commonest arrangements is shown in Fig. 253—the zigzag design used much on milling machine slides.

Floating rollers throw the oil up on the slides of the travelling tables of planers. A system of forced lubrication is adopted for the ways of Cincinnati planers. A pump is mounted at the rear of a housing and oil pumped into the ways near the centre of the bed whence it is distributed along the vees by zigzag grooves. The oil discharged into the pockets at the ends is returned to the tank to be strained before being again distributed.

Pad lubrication is used on the slides of many of the smaller machines. Pockets in the slide receive and enclose the pads, Fig. 254, which retain the oil and keep the slides lubricated without the need for constant attention. The oil is supplied to the pads through holes suitably disposed.

Fig. 255 illustrates a milling machine table with tee grooves and a waste oil tray surrounding. The projections on the under side extend beyond, and afford protection to the vee'd slides. These are lubricated from the hole in the table at the left, to be closed with a plug, diagonal channels passing thence down to the vee's and to the felt pads in pockets beneath. The channel to the right abutting on the tee groove for the dogs supplies the bearing for the feed screw.

Fig. 256 illustrates a method of fitting the table of a grinding machine with a vee'd take-up strip, and its lubrication. Bent oil tubes, closed with plugs, pass from the top of the table to the vee'd edges, and one to the central pinion shaft provided with a felt pad. The only objection to this method, and it is hardly one of moment except perhaps in cases where a large quantity of repetitive work is being done, is occupying the table for lengthy periods and covering up the oiling holes. Fig. 257 shows the table of a milling machine in plan. It has three tee grooves and two waste oil trays. The external drain pipe is connected to both of these.

Protection of Ways.—Methods of protecting slideways are illustrated. Fig. 258 shows a table or saddle extended to cover the ways along which it moves. In Fig. 259 a guard is screwed on the end of the table. Fig. 260 is a loose protective guard that can be slipped on and off over screw heads. Fig. 261 is a short extension lip cast on the end of a planer table. Fig. 262 is an improvement, since the extension screwed on not only protects but lubricates through the oil absorbent felt pad. Fig. 263 is the familiar water guard on the tables of cylindrical grinders that diverts the splashing water from the slides to the troughs.

Other provisions are made in some machines to keep the slides clear of cuttings, which would abrade the surfaces when pushed and rubbed over them. Very long protecting covers are used on some lathes, attached to saddles, and to grinder tables. An efficient method from one of the Lodge and Shipley lathes is shown by Fig. 264. A leather wiper or pad A is located in front of the slide, and in front of an oiling pad B, to clear the vees of cuttings in front of the saddle. Though the ways of many grinders and lathes are afforded protection thus, hardly any planers are so treated. Yet these are as liable to injury as any other machine tool. One method has been employed and patented. Two strips of heavy duck, wider than the ways, are mounted upon rollers or spools at the end of the bed, the other ends being attached to the end of the table. The shaft which carries the spools is actuated by a spring, like a window roller, to keep the duck taut in all positions, winding it up as the table approaches and allowing it to be unwound as the table moves away. A pair of rollers at the end keeps the strips clear of the ends of the bed.

A WORKSHOP VISCOSITY METER.

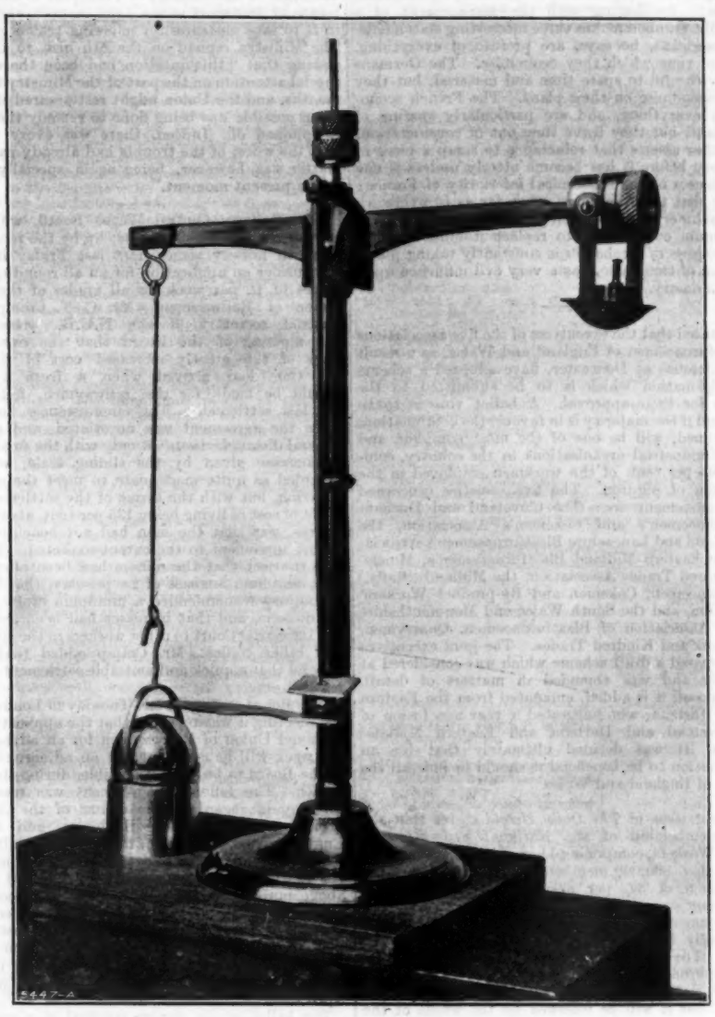


FIG. 1.

WE illustrate on this page a remarkably simple viscosity meter devised by Mr. A. G. M. Michell, of 450, Collins-street, Melbourne. The instrument is intended for ordinary everyday use in the workshop, and whilst giving rapidly determinations of viscosity in absolute measure requires no extraordinary care or skill in use.

It consists, as shown in Fig. 2, of two elements—a cup fitted with a handle and a ball of the same curvature as the cup. Actual contact between these two surfaces is prevented by three symmetrically disposed projections in the cup raised a mil. or two above its surface. In the ordinary use of the instrument the cup is held by its stem, and a few drops of the oil to be tested are placed in it. The ball is then placed in the cup and pressed firmly into it for 5 seconds or 10 seconds. This drives some of the oil out, which collects in the channel shown. Enough oil must be provided in the first instance to ensure that this channel is filled. The instrument is now inverted and the time taken for the ball to drop clear is noted. This time in seconds divided by the constant of the instrument is equal to the absolute viscosity of the oil. The action of the instrument depends upon the rate at which the oil film between the cup and the ball thickens under the force of gravity exerted by the ball. This flow of the oil is resisted by its viscosity, and the time taken for the ball to fall clear is accordingly directly proportional to this viscosity.

This method gives sufficiently accurate results for making comparisons in the workshop, but in this climate it has been found advisable to insulate the handle, to prevent the viscosity of the oil being affected by the heat of the hand.

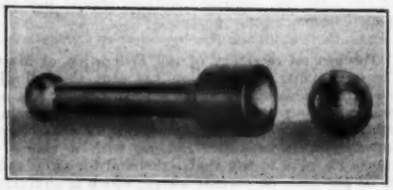


FIG. 2.

For accurate results an alternative method of using the instrument, is to place the ball at the bottom of a vessel containing a considerable quantity of the liquid. The cup is then lowered over the ball, taking care not to entrap air. After pressing the two together for 5 seconds or 10 seconds they are lifted till the ball clears the bottom of the vessel, and the time it takes to drop clear is noted as before. By using the instrument in this way the disturbing effects of surface tension, specific gravity, mean heads, etc., are reduced to negligible dimensions. Mr. W. Ramsay, F.I.C., Chemist to Messrs. Cammell and Laird, Birkenhead, states that operated in this way the instrument is probably the simplest and most accurate known. In his laboratory 120 most concordant readings have been obtained in two hours, whilst a comparison set of observations made with one of the older types of viscosimeters took nearly two days to complete. In spite of this, the results given by the Michell instrument plotted quite regularly, whilst the others did not fall accurately on to a smooth curve, and had, moreover, to be reduced to absolute measure, which the Michell instrument gives directly.

With liquids of very low viscosity the arrangement shown in Fig. 1 is employed. Here the cup is fixed in a vertical position, whilst the ball is suspended from the arm of a balance as indicated. By adjusting the weights the force tending to separate the ball from the cup can be diminished, say, to $\frac{1}{10}$ of the normal. This will increase twentyfold the time needed to effect the separation.

Each instrument is independently calibrated against a reliable absolute viscosity meter. The stem for the cup is hollow, to admit a thermometer for recording the temperature at which the test is made.

The instrument is, it will be seen, non-fragile and can be easily kept clean. The surfaces of the ball and the cup should be preserved uninjured either by rust or mechanical damage, and the magnetisation of either should be avoided, though if it occurs demagnetisation can be effected in the usual way.

The manufacture of the apparatus has been undertaken in this country by Michell Bearings Limited, 3, Central Buildings, London, S.W. 1.

NOTES ON NEW BOOKS.

In the present days of fuel scarcity a treatise dealing with heating is welcome. Such a treatise is entitled "*All About Anthracite*," by Mr. A. Leonard Summers, issued at 8*s.* 6*d.* net by The Technical Publishing Company, Limited, 1, Gough Square, Fleet Street, E.C. 4. It advocates the use of anthracite above all other classes of coal. Many members of the community have laid themselves out to do so in their households, but the difficulty is that they are unable to obtain the anthracite. The author is aware of that difficulty for he says "it behoves customers to be careful and on their guard against unscrupulous merchants or vendors, and to make quite sure that they really do obtain anthracite when ordering such." We find by experience that the consumer has but one remedy, namely, to burn the pseudo-anthracite as best he may and try to find a scrupulous merchant or vendor who will supply the real anthracite. The book deals in detail with the economics of fuel utilisation, and there are two statements given which are very striking when taken together. He says that the total of small coal cast back in the coalfields of Great Britain is 2,325,000 tons per annum (of which about 1,502,000 tons are Welsh); to our mind, this is a criminal proceeding. A market for this could certainly be found on the Continent; in this connection he describes the compound fuel, called "Pele," a mixture of small anthracite "duff" and common clay, which is largely used and has been known throughout Wales for centuries, though London and most cities of England have never heard of it. This mixture of fine coal with clay is one which, we may add, is well known in France. Small householders in the outskirts of French manufacturing cities can frequently be seen mixing their own "Pele," using for the purpose an ordinary mortar mixing shovel. In regard to patent fuel, "one of the greatest drawbacks of which is its inability to stand prolonged exposure to the weather," this forms the staple fuel for locomotives in France, and large stocks of coal briquettes are maintained in good condition at all the important railway junctions; the utilisation in Great Britain of coal slack in the form of briquettes might lead to a very important saving. The book further enters into the use of anthracite for industrial purposes, in gas-producers, &c. It emphasises also the advantages from the point of view of hygiene, resulting from its use in domestic fires and stoves, advantages which are quite obvious given the anthracite.

Before the war this country did not produce one-third of its zinc consumption; it was not prominent in the manufacture of roasting or distilling furnaces, nor of zinc retorts, and when the demand for zinc pressed, the dearth of skilled zinc smelters, whom experience alone could train, made itself severely felt. Want of raw materials, which in late decades Broken Hill and other British mines had supplied in ample quantity, was not responsible for the position. Nor was the industry foreign to the country. For the brothers Champion had started spelter works near Bristol about 1740. But they had brought men over from the Continent and the technical zinc processes had been worked out in Germany in times when Belgian formed part of the German Empire. Many things in zinc smelting are still known as Silesian, Rhenish, or Belgian, and are connected with German—or recently German-American—names. Yet the Champions feared Continental competition less than the imports from India and the East, where the Portuguese had found a spelter industry already developed, and William Champion's petition to Parliament of 1750 was against spelter imports from East India. The Champion works did not prosper. But the zinc industry of the country has now taken a remarkable rise,

and with that the English literature on the subject has gained in quantity and quality. The book on "*Zinc and Its Alloys*," by Mr. T. E. Lones, M.A., LL.D., published by Sir Isaac Pitman and Sons, at 2*s.* 6*d.* net, bound, is not compiled for the technical engineers. Yet it is a useful, handy book, and gives in its 127 pages much instructive information on the historical development of the spelter industry and its actual position. More should have been said on the difficulties of zinc distillation and on retorts, however. This section is decidedly poor, and we should also think in general that Mr. Lones might have gone further in subdividing his matter. Technical books are not read like novels.

One's first impulse on coming across a new book on machine drawing is usually to look through it for examples of the things which are only done in the technical school and never in the drawing office. Having just performed this operation with the "*Text Book on Machine Drawing for Electrical Engineers*," by Mr. Edward Blythe, we must confess it comes through the ordeal with credit. This is not to say, however, that we approve of everything in the book. There are, for instance, various hatchings and markings given for indicating 16 different materials on drawings. We can hardly think Mr. Blythe would contend that more than, say, half a dozen of these are in common use in practice. It is misleading a student to let him think that if he indulges in a certain type of broken cross-hatching, then his fellows in the drawing office of commerce and the everyday workshop will know that he is representing asbestos. In the matter of the examples which have been chosen, the book is on the whole excellent. The examples are taken from practice, and refer naturally to electrical apparatus and machines. We do not know that we have before come across a book catering for the beginner in the electrical drawing office. It should, perhaps, be said that the book refers only to the mechanical side of electrical design, and there are no winding diagrams and no information in reference to the lay out of coils, formers, &c. The book forms one of the Cambridge Technical Series, and is published by the Cambridge University Press at 20*s.* net.

INDUSTRIAL NOTES.

THE National Federation of General Workers met in conference at Essex Hall, Strand, London, on the 8th inst., to discuss the methods followed for obtaining decisions in regard to wages by means of the Whitley Councils. Mr. J. R. Clynes, M.P., who was in the chair, said he looked on the headway made in connection with the Joint Industrial Councils as denoting a very remarkable advance in the sphere of industrial conciliation, although he agreed there were blemishes in their working. Some of the large trade unions, he added, preferred their organisations to the machinery of Industrial Councils, and although these large organisations could perhaps afford to retain the machinery in question and secure what they thought they were entitled to by ordinary trade union methods, there were 3,000,000 wage earners outside these organisations covered by the Joint Industrial Councils. On the other hand, there were some who refused to recognise the Councils because they were trafficking with the capitalisation system; therefore, they said the Federation should have nothing to do with them. He maintained that they should come down to the actualities of life; they could not afford to live in the clouds in that way. One point, however, they had to note, and it was to the effect that the Joint Industrial Councils tended to become very costly machinery for the trade unions in two ways: (1) In money charges imposed on trade unions, and (2) in regard to the enormous amount of time they required from the active executive heads and responsible administrative officers. Mr. Clynes reviewed other points in his speech, and added that the Federation had invited the representatives of affiliated unions to meet, not in any spirit of hostility to the councils, but in order that they might have an interchange of opinion and locate, and, if possible, remove the defects of the present system. They would be asked to decide, as a matter of policy, whether as representing the affiliated unions they were in favour of contin uing to associate with the Councils set up under the Whitley Report. At the conclusion of the conference, Mr. Clynes stated that the discussion showed that the representatives were on the whole favourable to the continuance of the Joint Industrial Councils, and that complaints were limited to a few particular Councils, dealing with certain trades. The following resolution was unanimously carried:—"That the members of this conference, while agreeing with the general principle of Whitley Councils, consider that the Executive Committee of the National Federation of General Workers should call a joint conference of representatives of the executives of the affiliated unions, together with delegates from the conference of Joint Industrial Councils, for the purpose of devising ways and means for making these Councils more useful to the workers concerned."

We read in the French journal *L'Avenir* that Mr. Victor Cambon has recently published in book form his lectures to the Paris Ecole Centrale des Arts et Manufactures, on the "Organisation of Industry by American Methods." In dealing with the management of a works, Mr. Cambon makes three interesting statements. The Americans, he says, are profuse of everything, except of time which they economise. The Germans are very careful to spare time and material, but they do not economise on their plant. The French economise on everything, and are particularly sparing of their plant, but they leave time out of consideration. The author asserts that reluctance to scrap a piece of machinery before it has become utterly useless is one of the causes of the economical inferiority of France; he adds that the Americans go so far as to overwork their machinery, not so much perhaps to obtain from it a maximum output, but to replace it more rapidly, since progress in mechanics is constantly taking place. Disregard of time, also, has a very evil influence upon French industry.

It is stated that the executives of the five associations of Blastfurnacemen of England and Wales, as a result of a conference at Doncaster, have adopted a scheme of amalgamation which is to be submitted to the districts for their approval. A ballot vote is to be taken, and if the majority is in favour, the combination, it is claimed, will be one of the most complete and powerful industrial organisations in the country, comprising 95 per cent. of the workmen employed in the production of pig-iron. The five societies concerned in this movement are: The Cleveland and Durham Blastfurnacemen's and Cokemen's Association, the Cumberland and Lancashire Blastfurnacemen's Association, the Eastern Midland Blastfurnacemen's, Miners' and Kindred Trades Association, the Midland (Staffs.) Blastfurnacemen, Cokemen and By-product Workers' Association, and the South Wales and Monmouthshire District Association of Blastfurnacemen, Quarrymen, Ore Miners and Kindred Trades. The joint executives have prepared a draft scheme which was considered at Doncaster and was amended in matters of detail. The proposal, it is added, emanated from the Eastern Midland District, who suggested a year ago fusion of the Cleveland and Durham and Eastern Midland Districts. It was decided ultimately that for an amalgamation to be beneficial it should include all the districts of England and Wales.

A recent issue of *The Daily Herald* states that the whole membership of the National Federation of General Workers, comprising 11 unions, with a strength of more than 990,000 members, will refuse to pay the contribution of 3*d.* per head per week under the Government's new scheme for general insurance against unemployment, if the capitalist insurance trusts and the friendly societies are allowed to administer the scheme. The National Federation of General Workers is, the journal believes, the first union to take preparatory steps for drastic action if the amendment stands. But it will be followed by the whole of the trade unions, who may be counted upon to give effect to the advice which will be given by the Parliamentary Committee of the Trades Union Congress, that none of the 5,000,000 organised workers should pay their contribution.

The general secretary of the Federation of Master Cotton Spinners' Association has sent the following reply to the claim put forward by the operatives and referred to on page 487 *ante*: "We have very carefully considered your claim and the arguments you have put forward in its support. Dealing with it clause by clause we have to say that a demand for an advance of 60 per cent. on current wages, which is equivalent to an additional 147 per cent. on the basis of the list, is, in our opinion, so excessive as to make the possibility of an agreement on this part of your case most improbable. With your claim for payment for annual summer holidays we cannot agree. On the third clause in your demand, in which you claim that 'any agreement arrived at shall only be provisional, and we reserve the right to repudiate such agreement in the event of any other section of workers being granted more favourable terms than those which may be embodied in such provisional agreement' we feel very strongly. We note your explanation, but, in our opinion, any agreement which gives one party to its terms the absolute right to repudiate it without the consent of the other party is so foreign to all ideas of fair play that in simple justice to our members we must definitely decline to entertain it. Under all the circumstances we must decline to agree to your wages demand, and we make you the definite proposal that same be submitted to Government arbitration."

The Palmer Shipbuilding and Iron Company, last Friday, issued a notice saying that owing to congestion of material and transport difficulties they were compelled to stop their 36-in. mill at their steel works during the present week. The British Commonwealth Union, 24, Abingdon-street, Westminster, called the attention of the Ministry of Transport to the defective means of transport in the Tyne district, and appealed to it to take measures for relieving traffic congestion. The Ministry replied on the 8th inst. to the Union, stating that "this question had been the subject of special attention on the part of the Ministry for several months, and the Union might rest assured that everything possible was being done to remedy the situation complained of. Indeed, there was every indication that the worst of the trouble had already passed. The matter was, however, being again specially reviewed at the present moment."

The Railway Central Wages Board, which forms part of the new machinery set up by the recent settlement in railway wages, met last Friday in London to consider an application for an all-round advance in wages of 1*l.* per week for all grades of the National Union of Railwaymen. Mr. C. T. Cramp, the industrial secretary of the N.U.R., stated before the meeting of the Board that the executive, in view of the greatly increased cost of living, felt the time had arrived when a fresh application should be made for the railwaymen, following on the last settlement. The circumstances had altered since the agreement was negotiated, and there was general dissatisfaction, not only with the small amount of increase given by the sliding scale, which was regarded as quite inadequate to meet the extra cost of living, but with the terms of the settlement. The effect of cost of living being 135 per cent. above pre-war figures, was that the men had not benefited by the recent agreement to the extent expected. There was also the fact that the miners had been offered a flat rate minimum increase of 2*s.* per day, that the Court of Inquiry recommended a minimum of 16*s.* per day for dockers, and that increases had been awarded by the Industrial Court to other workers in the engineering and other trades. Mr. Cramp added that he was hopeful that a quick and amicable settlement would be reached.

The Board met again last Tuesday in London; after the meeting it was reported that the application of the National Union of Railwaymen for an advance of 1*l.* per week will be considered at an adjourned meeting of the Board to be held, if possible, during the present month. The following agreement was reached last Tuesday in regard to the claims of the Associated Society of Locomotive Engineers and Firemen: Engine drivers, motormen, firemen and adult cleaners will receive an advance of 1*s.* per week from November 1, when the cost of living stood at 120 per cent. above normal, an advance of 2*s.* from December 1, when the cost of living stood at 125 per cent. above normal, and 3*s.* from March 1, when the cost of living was 130 per cent. above normal; all men in other conciliation grades, except engine men, are to receive an advance under the sliding scale of 1*s.* per week from April 1.

The ballot of the miners resulted in a majority in favour of the acceptance of the Government terms—442,704 voting in favour, and 377,560 for a strike. There will therefore be no strike.

WILLING'S PRESS GUIDE.—A copy of the current edition of this very useful publication, which has now reached its forty-seventh annual issue, has recently come to hand. A considerable portion of the book is occupied by an alphabetical list of newspapers and periodicals issued in the United Kingdom, the year of establishment, date published, price, and publisher's name and address being given in each case. Another useful feature is a list of papers classified in accordance with the interests, professions, trades, or subjects dealt with, and similar lists, classified according to locality, are also included. Particulars are also given of the principal newspapers issued in the Colonies, India, Africa, Asia, America, and in Continental countries. The price of the guide, bound in paper-covered boards with cloth back, is 2*s.*, and it is published by Messrs. James Willing, Limited, at 125, Strand, London, W.C. 2.

PROPOSED NEW DRY DOCK AT VANCOUVER.—H.M. Senior Trade Commissioner at Montreal has forwarded to the Department of Overseas Trade the following information on the above subject: Messrs. H. Coughlan and Sons, Limited, Vancouver, B.C., have at present an application before the Department of Public Works, Ottawa, under the Dry Dock Subsidies Act, for the construction of a second-class graving dock, upon which subsidy may be paid for a period of thirty-five years, at 4½ per cent., semi-annually, on the maximum of 2,500,000 dols. The proposed site of the dock is on Burrard Inlet, B.C., having 200 ft. of water frontage, but the size of the dock although it will carry only second-class subsidy, will be somewhat larger than the minimum dimensions required by the Act for second-class graving docks. The Coughlan application is for a dock of the following dimensions: Length from caisson stop to head wall, 725 ft.; length from back of sill to head wall, 700 ft.; clear width of entrance at bottom, 110 ft.; depth over sill at high water, O.S.T., 30 ft.

LOAD FACTORS FOR AEROPLANES AND SEAPLANES.

WHEN the employment of aircraft for civil purposes became practicable, owing to the termination of hostilities, representatives of the aircraft industry pointed out the necessity for arriving at an agreement as to the load factors to be worked to in designing commercial aircraft. Although knowledge on this subject had increased very largely during the war, the bases and methods upon which designers worked varied considerably, and it was obvious that the matter was one requiring careful technical investigation. The Air Council, therefore, requested the Advisory Committee for Aeronautics to appoint a sub-committee—upon which the various interested bodies should be represented—to consider and report as to the definite rules which should be adopted to govern the load factors required for all classes of civil aircraft, and upon which certificates of airworthiness may be based. The sub-committee was composed of the chairman of the Advisory Committee for Aeronautics (*ex-officio*); Lieutenant-Colonel W. D. Beatty and Squadron-Leader F. H. Bramwell, representing the Air Council; Lieutenant-Colonel O'Gorman and Mr. L. Bairstow, representing the Royal Aeronautical Society; Mr. F. Handley Page, Captain F. S. Barnwell, Mr. H. Smith and Mr. H. O. Short, representing the Society of British Aircraft Constructors; and Professor J. E. Petavel, Mr. F. W. Lanchester, Mr. R. V. Southwell and Dr. T. E. Stanton, representing the Advisory Committee for Aeronautics. The unanimous report of this sub-committee, which has now been approved, is given below, and its provisions will be made applicable to designs submitted to the Director of Research after the 15th of March.

SCHEDULE OF LOAD FACTORS FOR HEAVIER-THAN-AIR CRAFT.

Heavier-than-air craft are now used for a variety of purposes including, on the one hand, purely commercial work and, on the other, "stunt" flying. The strength necessary for safety is different in the two classes; for the former class the specification need not be so exacting as for the latter in order to ensure adequate safety; further, a lower factor is commercially desirable since an increase of load factor involves a decrease in the range and load-carrying capacity. Heavier-than-air craft have, therefore, been divided into two classes having regard to the different qualities of airworthiness required. This separation will necessitate the granting of two distinct types of certificates; it has been suggested that these should be readily distinguishable by the use of different colours or other means. The aircraft in the "General" Class, including all those not in the "Commercial" Class, should be sufficiently strong to allow of stunt flying of all descriptions. The other class, "Commercial," will include craft used for strictly commercial work involving only straight flying; stunting of any kind will be prohibited. The schedule below is given in tabular form under these two heads.

In preparing this schedule the Load Factor Sub-Committee of the Advisory Committee for Aeronautics considered only future designs; it is not intended that the schedule should be made applicable to machines already approved or designs submitted prior to some future date to be fixed by the Air Ministry. Further revision of the present schedule from time to time will, doubtless, be necessary in order that it may remain in accordance with the demands arising from improvements in constructional methods and design.

Method of Specifying Strength.—The first specification (*a*) determines the load factor when the centre of pressure is in its most forward position; this gives in each case a definite load for every part of the machine, including the tail plane and the fuselage. The second specification (*b*) gives the load factor when the centre of pressure is in the position corresponding to maximum horizontal speed at ground level; this also gives a definite loading. The next specification (*c*) gives the factor of safety in a terminal nose dive, a condition which is, again, quite definite for each aircraft, the aircrews being assumed to be removed. The above are considered sufficient to determine the strength of the wings and of the tail plane; also for certain loadings of the fuselage when in flight.

For the strength of the fin and rudder, specification (*d*) gives the value of an assumed lift coefficient, which, when the maximum speed of the craft is known, determines uniquely the strength required in these parts, and also, in so far as the lateral loadings are concerned, in the fuselage; the values assumed for the lift coefficient are considered sufficient to cover adequately the maximum forces which can be imposed on the rudder and fin by the pilot when exerting his full force so as to obtain as rapid a turn as possible. Strength of undercarriages—specification (*e*)—is dealt with under the conditions of both static and dynamic loads, neither case being considered sufficient by itself to meet all requirements.

For the use of the tables it should be noted that the two terms, factor of safety and load factor, are defined in the accepted engineering sense, *i.e.* :—

$$\text{Factor of Safety} = \frac{\text{Failing strength of a member of the structure}}{\text{Worst possible load occurring under any condition of flight.}}$$

$$\text{Load factor} = \frac{\text{Failing strength of a member of the structure.}}{\text{Load in member under horizontal steady flight conditions.}}$$

In addition to the above it is essential (*f*) that, in the case of any one flying wire, or duplicate pair of wires, being removed from the aircraft, the strength of the remaining portion should be such that at least one-half of the scheduled load factors and factors of safety should be obtained under each of the foregoing conditions. For this particular case incidence, or other normally redundant, bracing is naturally assumed operative where necessary.

TABLE I.—*Commercial Class.*

—	Total Weight of Aircraft. Up to 5,000 Lb.	5,000 Lb. to 10,000 Lb.	10,000 Lb. to 30,000 Lb.	Above 30,000 Lb.
(*a*) Load factor with C.P. in its most forward position	6†	6†–5*†	5†–4*	4
(*b*) Load factor with C.P. in the position corresponding to maximum horizontal speed at ground level	4·5†	4·5†–3·75*†	3·75†–3*	3
(*c*) Factor of safety in terminal nose dive	1·75†	1·75†	1·75†	1·75†
(*d*) Specified lift coefficient for fins and rudders. (Under this loading the factor of safety of the fuselage should be unity.)	0·5	0·5	0·5	0·5
(*e*1) Static load factor on undercarriages	6	6–5*	5–4*	4
(*e*2) Specified vertical velocity (ft./sec.) for determining travel of undercarriages	10	10	10	10

* The decrease in load factor from the larger value is directly proportional to the increase in the weight of the craft.
† In the case of aircraft which are longitudinally stable over the whole flying range, these figures may be reduced by 0·5.

TABLE II.—*General Class.*

—	Total Weight of Aircraft. Up to 3,000 Lb.	3,000 Lb. to 10,000 Lb.	Above 10,000 Lb.
(*a*) Load factor with C.P. in most forward position	8	8–6*	6
(*b*) Load factor with C.P. in the position corresponding to maximum horizontal speed at ground level	6	6–4·5*	4·5
(*c*) Factor of safety in a terminal	1·75	1·75	1·75
(*d*) Specified lift coefficient for fins and rudders. (Under this loading the factor of safety of the fuselage should be unity)	0·6	0·6	0·6
(*e*1) Static load factor on undercarriages	8	8–6*	6
(*e*2) Specified vertical velocity (ft./sec.) for determining travel of undercarriages	10	10	10

* The decrease in load from the larger value is directly proportional to the increase in the weight of the craft.

Methods of Calculation.—In using the above schedules the calculations of strength will be checked by the methods of the "Handbook of Strength Calculations" (H.B. 806, second edition), published by the Technical Department, Air Ministry. In all calculations, and in specifications of load factors and factors of safety, design figures should be employed and not those obtained from breaking tests. Further, when dealing with steel tubes, the specifications of the Engineering Standards Committee based on the figures for yield-points, are approved for stress calculation purposes; for stream-line wires, the breaking load should be taken in preference to the yield-point, which is, in these cases, ill-defined. Redundant wires, except as mentioned in (*f*), are to be considered as neglected.

With a view to facilitating the use of the schedule the following additional matter should be noted :—

1. That for (*a*) and (*b*) the positions of the centre of pressure should, preferably, be determined by a test on a model with a 6-in. chord at 60 ft./sec., but that the Air Ministry might agree to issue a certificate based on results for a monoplane model of 3-in. chord tested at 40 ft./sec. For biplanes, a biplane test is preferred; similarly for triplanes.

For case (*b*) the maximum horizontal speed at ground level should be obtained from the formulæ given in (2) below. From this speed the value of the lift coefficient is obtained and the position of the centre of pressure determined from model tests as defined above.

(2) That for (*b*) and (*d*) the maximum speed at ground level should be defined by the following formulæ giving the maximum speed for given loadings and weights of aircraft; should the manufacturer desire to specify the maximum speed in any other manner he is at liberty to make a special application.

For single-engine aircraft :

$$\left(V\sqrt{\frac{\rho}{\omega}} - 1{\cdot}425\right)^2 = 2{\cdot}74\left(N\sqrt{\frac{\rho}{\omega}} - 0{\cdot}304\right).$$

For multi-engine aircraft :

$$\left(V\sqrt{\frac{\rho}{\omega}} - 1{\cdot}84\right)^2 = 2{\cdot}99\left(N\sqrt{\frac{\rho}{\omega}} - 0{\cdot}310\right).$$

For boat seaplanes :

$$\left(V\sqrt{\frac{\rho}{\omega}} - 1{\cdot}425\right)^2 = 2{\cdot}74\left(N\sqrt{\frac{\rho}{\omega}} - 0{\cdot}304\right).$$

where N, V, ω and ρ are the power per unit weight, the speed, the loading, and the density in any system of consistent units, *e.g.*, N in ft./lb. per sec. per lb., V in ft.-sec., ω in lb./sq. ft., and ρ in slugs/cub. ft. (at ground level).

The above formulæ may also be expressed in the form :—

For single-engine aircraft :

$$\left(\frac{V}{\sqrt{\omega}} - 25\right)^2 = 16{\cdot}6\left(\frac{N}{\sqrt{\omega}} - 11{\cdot}8\right).$$

For multi-engine aircraft :

$$\left(\frac{V}{\sqrt{\omega}} - 23\right)^2 = 15{\cdot}7\left(\frac{N}{\sqrt{\omega}} - 11{\cdot}6\right).$$

For boat seaplanes :

$$\left(\frac{V}{\sqrt{\omega}} - 20\right)^2 = 14{\cdot}4\left(\frac{N}{\sqrt{\omega}} - 11{\cdot}35\right).$$

where N is horse-power per 1,000 lb. $\left(i.e., \frac{1{,}000 \text{ H.P.}}{W}\right)$ W being the weight and H.P. the horse-power of the aircraft in question. V is in miles per hour at groun l level and ω is the wing loading in pounds per square foot.

(3) That for (*c*), the case of the limiting nose dive calculations submitted by the manufacturers would be considered by the Air Ministry; otherwise, the following table with the necessary extensions for other wing sections would be employed.

TABLE III.—*Tail Plane Loads in Limiting Nose Dive.*

Type of Aircraft.	Wing Section Employed. R.A.F. 15.	R.A.F. 6 C.
Single engine	$0{\cdot}6\,\frac{We}{l}$	$0{\cdot}9\,\frac{We}{l}$
Multi-engine	$0{\cdot}55\,\frac{We}{l}$	$0{\cdot}7\,\frac{We}{l}$
Boat seaplane	$0{\cdot}5\,\frac{We}{l}$	$0{\cdot}8\,\frac{We}{l}$

where W is the weight of the aircraft, e is the chord of the main planes, and l is the distance from the centre of gravity of the aircraft to the centre of pressure of the tail plane.

(4) That in the case of (*d*) the static strength of the undercarriage should be checked for the four following cases :—

(i) When the aircraft lands on an even keel and w th the chord of the main planes horizontal.

(ii) When the aircraft lands on an even keel and so that the tail skid and undercarriage touch the ground simultaneously.

(iii) When the aircraft lands so that one wing tip touches the ground at the same time as the main undercarriage and with the chord of the main planes horizontal.

(iv) When the aircraft lands so that one wing tip touches the ground at the same time as the main undercarriage and so that the tail skid and undercarriage touch the ground simultaneously.

In (i) and (ii) the load factor should be that specified, and in (iii) and (iv) the load factor should be at least half that specified.

As regards length of travel of the undercarriage, its amount should be such that the total work of compression is equal to the value of $\frac{1}{2}(w\,v^2)/g$, where w is the weight of the machine and v is the specified vertical velocity; also, the maximum load should not exceed the specified static load on the undercarriage.

THE BRITISH CHAMBER OF COMMERCE IN BELGIUM.—The tenth annual report of this Chamber, for the year 1919, has now been issued. In this, the council state that the Chamber is now in full working order and busily engaged in doing all in its power to further British trade interests in Belgium. Its address is 2, Rue de la Bourse, Brussels.

DEGREES AT THE IMPERIAL COLLEGE.—We gather from the remarks of the Marquess of Crewe, K.G., delivered on Friday last at the dinner of the Institution of Mining and Metallurgy, that a movement is on foot to raise the Imperial College of Science and Technology to the rank of a university. The college, it will be remembered, was formed some few years ago by the incorporation of the Royal College of Science, the Royal School of Mines and the City and Guilds Institute at South Kensington, and it is now one of the most important colleges of the University of London. Employers, especially those in the Dominions and abroad, Lord Crewe pointed out, attached great importance to the possession of a university degree, so that a qualification of this nature was almost essential in order to obtain a high position as a mining engineer. For this reason, a student, after passing through the Royal School of Mines, had to do over again work he had already accomplished to the satisfaction of persons most competent to judge, in order to obtain a B.Sc. degree at the London University. This was regarded as a serious hardship, and had led to the movement to obtain powers for the Imperial College itself to grant degrees. Professors, teachers and students at the college were all in favour of the change, and this being so, the governors would do their best to induce the Government to accede to their request.

THE SCHNEIDER 155-MM. GUN.

Fig. 1. GUN IN FIRING POSITION.

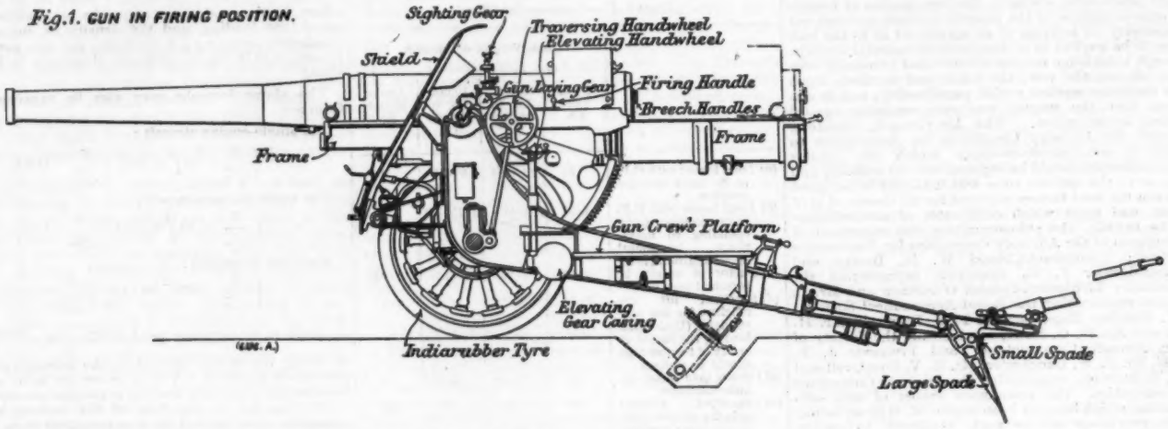


Fig. 2. GUN READY FOR THE ROAD.

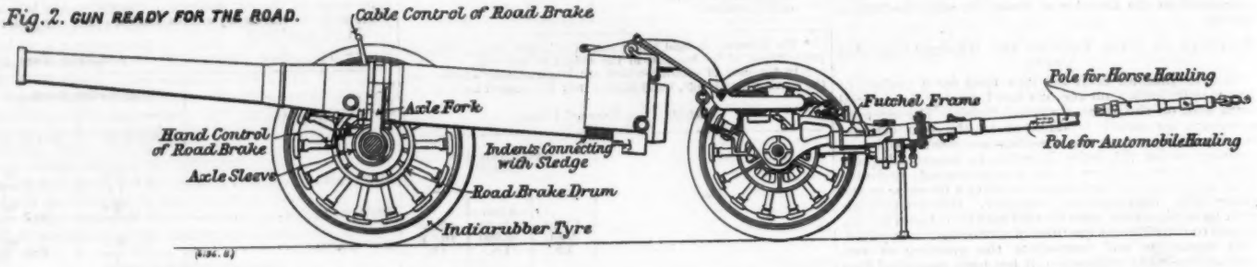
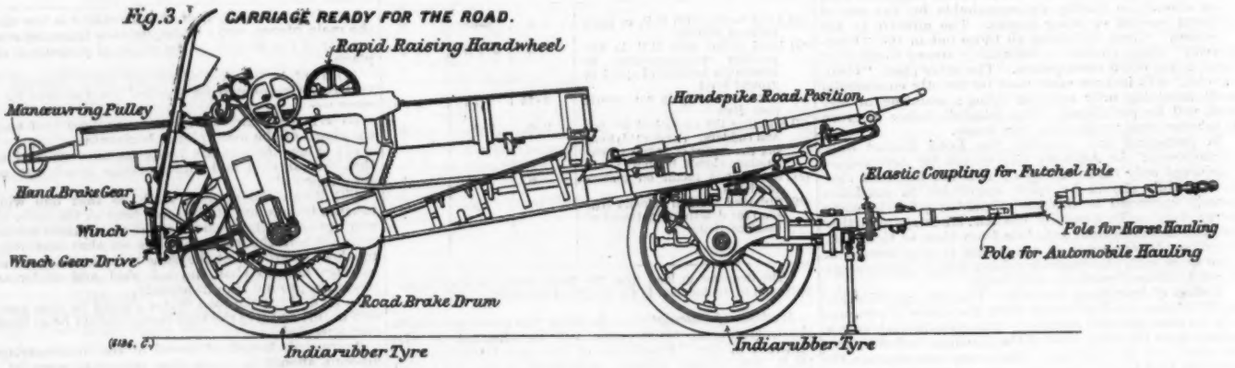


Fig. 3. CARRIAGE READY FOR THE ROAD.



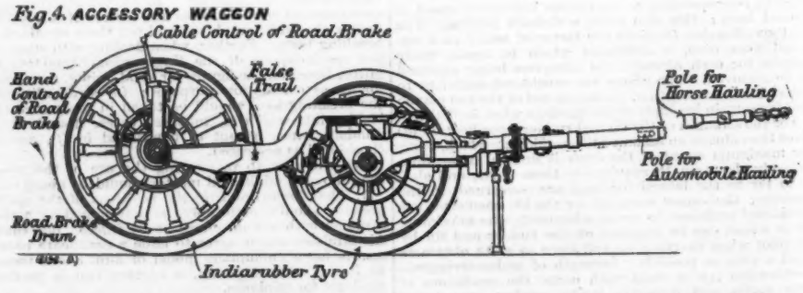
THE SCHNEIDER 155-MM. GUN.

In a former article* we gave a description of the 155-mm. Schneider howitzer and of the hydraulic recoil buffer and hydro-pneumatic recuperator with which it is provided to run up the piece to firing position at each round. The 155-mm. Schneider gun, like their 155-mm. howitzer, also forms part of the armament of heavy field artillery; it allows of firing at a flat trajectory and high-angle fire up to a positive angle of 40 deg. The 1917 pattern gun is shown in Figs. 1 to 6, whilst Fig. 7 illustrates a gun of the same calibre built in 1918. In order to reduce the wear of the tube and for medium ranges a reduced powder charge is used, corresponding with the reduced ranges. The maximum range exceeds 16,000 m. (10 miles) with a projectile weighing 43 kg. (94·770 lb.), containing 7·150 kg. (15·758 lb.) of explosive charge, the muzzle velocity being 670 m. (2,198 ft.). The gun like the howitzer, fires from the carriage without any preparation or platform. Three rounds can easily be fired per minute, a rate which can be increased to five rounds. For the road, the *materiel* forms a gun team and a gun-carriage team. Hauling is by automobile, but the weight of either team does not preclude horse traction. The time taken for passing from formation for the road in two teams to firing position, and *vice versa*, is about 20 minutes. The only apparatus required for this are a winch fitted to the carriage and ordinary lifting jacks. Over short distances, the gun can be wheeled, as it stands. The wheels of the 1917 gun are fitted with indiarubber tyres.

The gun consists of the gun proper, with its breech block, the sledge, frame, cradle, carriage, carriage after-body, false trail and gun and carriage limbers. The gun in the firing position is shown in Figs. 1 and 5, whilst Figs. 2, 3, and 6 illustrate the gun team and the carriage team. The gun is of steel, and consists of a tube, a jacket and a rear block forming an equalising weight. It is provided with the connections to the sledge and fixings to facilitate manœuvres. The breech is closed by an interrupted screw breech mechanism with plastic obturator, operated by hand and turning to the right-hand side. Firing is by percussion, the device not acting until the breech is completely closed. The gun, carriage and detail parts are generally similar to the corresponding parts forming the howitzer and the rifling is the same. Some other of the characteristic features of the 1917 gun are given in an appended table.

* See page 443 *ante*.

Fig. 4. ACCESSORY WAGGON



Particulars of Schneider 155-mm. Gun.

	M.	Ft.	In.
Total length of gun ...	4·950 =	16	3
Height of line of departure	1·855 =	6	1
Height of line of sight ...	2·200 =	7	2⅞
Length of gun in firing position	8·200 =	26	11
Limit of elevation... ...	— 5 deg. to + 40 deg.		
Limit of traversing, each side	2° 30′		
	Kg.		Lb.
Weight of gun complete ...	3,769 =		8,307
Weight of cradle	972 =		2,142
Weight of frame	727 =		1,602
Weight of carriage ...	3,298 =		7,269
Weight of gun in firing position	8,766 =		19,320
Weight of breech block ...	74 =		163
Weight of shield	120 =		264

THE SCHNEIDER 155-MM. GUN.

FIG. 5. GUN OF 1917 PATTERN AT MAXIMUM ELEVATION.

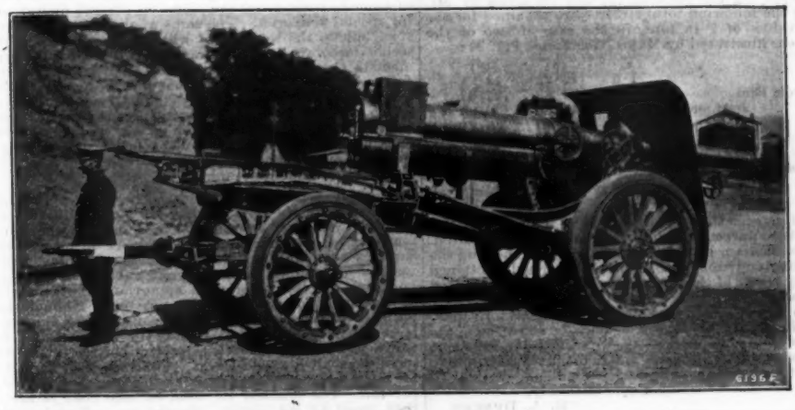


FIG. 6. GUN OF 1917 PATTERN READY FOR WHEELING.

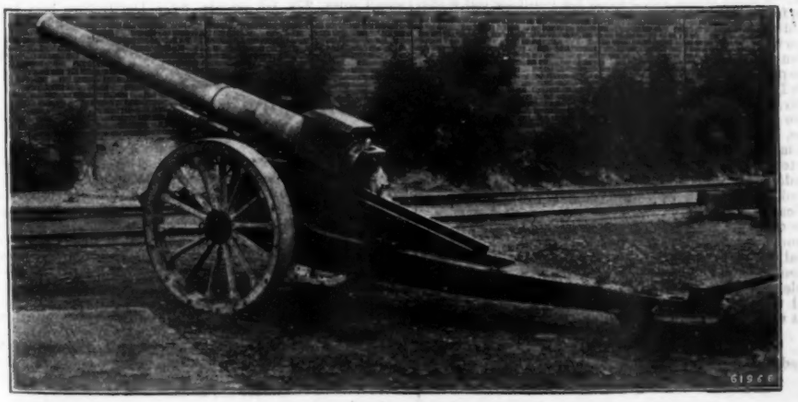


FIG. 7. GUN BUILT IN 1918 IN FIRING POSITION.

Front Teams.	*M.*	Ft.	In.
Diameter of wheels ...	*1·350* =	4	5
Wheel track, carriage ...	*1·658* =	5	5
Wheel track, gun carrier ...	*1·473* =	4	10
Width of steel tyres ...	*0·178* =	0	7
Width of indiarubber tyres	*0·150* =	0	5⅞

Front Teams.	*Kg.*	Lb.
Weight of pair of wheels ...	*530* =	1,168
Weight of front team, carriage team	*873* =	1,924
Weight of front team, gun-carrier team ...	*920* =	2,028

Rear Teams.	*M.*	Ft.	In.
Diameter of wheels ...	*1·520* =	4	11⅞
Wheel track, carriage ...	*1·870* =	6	1½
Wheel track, gun carrier ...	*1·974* =	6	5¼
Width of steel tyres ...	*0·265* =	0	10⅞
Width of indiarubber tyres	*0·225* =	0	8⅞
	Kg.		Lb.
Weight of pair of wheels ...	*980* =		2,160
Weight of false trail ...	*144* =		317
Weight of rear team carriage	*4,997* =		11,013
Weight of rear team gun carrier	*1,406* =		3,099
Gun in Travelling Trim.			
Carriage team (sledge, frame, carriage and carriage, front team) ...	*5,870* =		12,937
Gun team (gun, gun-carrier front and rear team, false trail)	*6,239* =		13,751
For Short Distances.			
Mounted gun (carriage and gun complete)	*9,639* =		21,244
Accessory team (gun team above, less gun)... ...	*2,470* =		5,444

The hydraulic recoil buffer and hydro-pneumatic running-up device are the same as those fitted to the howitzer.

18-IN. HIGH-SPEED SLIDING AND SURFACING LATHE.

A HEAVY type of high-speed lathe, constructed by Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, Manchester, and shown by them at the recent Lyons Fair, as a maximum production machine, is illustrated on page 516 of this week's issue. Fig. 1 gives a general view of this lathe which has 18 in. centres and is driven by a 60-h.p. variable-speed electric motor. Elevation and plan of the machine are shown respectively in Figs. 2 and 3. An end view of the fast headstock end is shown in Fig. 4; Fig. 5 gives a cross-section of the ways, while Figs. 6 and 7 are details of the loose bearing for the faceplate pinion.

The general features of this machine will be clear from our illustrations. The main spindle runs in phosphor-bronze bearings and is fitted with collars to take up the thrust. The four independent jaw chuck screws on to the spindle nose. The back of the face plate is fitted with a wheel having single helical teeth cut at 10 deg. All gears in the fast headstock are of this type cut from the solid. The gear ratios of the spindle drive are 11 and 30½ to 1, and with the variable speed motor running with a range of 250 r.p.m. to 750 r.p.m., give spindle speeds from 8·26 r.p.m. to 68·18 r.p.m. The lever for changing gears is the uppermost of the three in the fast headstock end, and may be clearly seen in Figs. 1 and 2.

The saddle has sliding faces, 54 in. long, and moves on two flat ways, each 9¾ in. broad. It has both a back and a front tool rest. The sliding speeds are changed by two levers below the fast headstock, giving 2, 3, 4, 8, 12 and 16 cuts per revolution of the spindle. This movement is transmitted to the saddle by pinions gearing with inverted racks on the front and back of the bed, the pinions being driven by the feedshaft in front of the machine. The surfacing feed is controlled by a lever on the saddle giving the same rates as for the sliding traverse. Both the front and back tool rests can be regulated independently by hand by spindles shown in Fig. 3. Hand sliding traverse is also arranged for the saddle. A safety catch is arranged at either end of the bed to prevent the saddle over-running, and the feed shaft is provided with a safety clutch.

The loose headstock calls for no particular comment. It is particularly intended to stand up to heavy work. The centre of the lathe is 3 ft. 9 in. above floor level, and the bed is 20 ft. long, though any other length of bed can be supplied. The machine illustrated will take work 10ft. long between centres. With Q.W. high-speed steel this machine will remove 2,545 lb. of forged steel per hour.

ULTRA-RAPID KINEMATOGRAPH.—For ballistic work the ordinary kinematograph, even when taking 3,000 pictures per second as the Bull apparatus of the Institut Marey in Paris, is too slow. By a modification of the electric devices used by Bull for producing a rapid succession of sparks, H. Abraham, E. Bloch and L. Bloch (*Comptes Rendus*, December 1, last) raise the number of possible pictures to 20,000 and even 50,000 per second. The idea is that a condenser of low capacity is charged, discharged, and immediately afterwards recharged by overflow from a condenser of high capacity. The essential parts of the instrument are an induction coil, charged to high potential, and several parallel secondary circuits. The first shunt comprises a resistance and a thermoionic valve; the second a condenser of 0·5 microfarad; the third a Leyden jar of 0·001 microfarad in series to an adjustable liquid resistance. This jar is itself shunted by a spark gap consisting of two semi-spherical knobs of aluminium, 1 mm. apart. The circuits also comprise several interrupters and an arc-extinguishing device.

"THE CAMMELLAIRD-FULLAGAR ENGINE."

TO THE EDITOR OF ENGINEERING.

SIR,—Will you please allow me to repeat a few points already mentioned in my previous letters, which Mr. Leitch has either not read or else has misunderstood.

1. My criticism was of the published design of the Cammellaird-Fullagar engine, and did not cover various modifications and additions which *might* be made subsequently.

2. Of course the lower pistons can be cooled by any of the well-known methods of piston cooling, but I merely referred to the lower pistons to show that the design could not use sea water for piston cooling. The upper pistons, however, at which leakage would be so objectionable, can only be cooled by using a system in which all pipes are under pressure, necessitating moving joints in rubbing contact, which have to withstand this pressure. Mr. Leitch is surely aware of the evils of this system, but perhaps he is not aware that the trouble has been entirely overcome, by a pressure-jet system with an open drain at atmospheric pressure. Such a system could not be fitted to the upper pistons of the Cammellaird-Fullagar engine.

3. I certainly did question whether the Cammellaird-Fullagar engine could be supercharged "in a much simpler fashion" than the Sulzer engine, but I never expected that such an utterly inefficient and undesirable feature as throttling the exhaust for this purpose would be seriously put forward. The question of supercharging, arose through the *argumentum ad ignorantiam* methods of the original article, which purported to show various methods of charging two-cycle engines, and the only design referring to the port scavenging type was the one labelled "B." No reference was made to the latest and most widely-adopted controlled port design, of which there is in successful service over 300,000 brake horse-power in Diesel engines, which design can supercharge without the addition of any extra gear. Supercharging by throttling the exhaust was very fully dealt with by Professor H. Junker as long ago as 1911, before a German engineering society, and perhaps Mr. Leitch will indicate the success this system has attained since this date, by stating how many hundred thousand horse-power are now in successful operation.

In conclusion, let me say that whilst welcoming any well-considered and relevant criticism on the various points I have raised, I find it extremely difficult to deal adequately with statements which evince an entire misapprehension of the real issues and appear to be chiefly concerned with trying to score dialectic points.

One little personal word, Mr. Leitch courteously describes the conclusions I arrive at as an "*argumentum ad ignorantiam*." The Imperial Dictionary translates this as "an argument founded on the ignorance of the adversary." It certainly was not this, nor was it intended to be so, but so far as your new correspondent is concerned, it appears to me that if it had been, its cogency would not have been impaired in the least.

Yours truly,

P. N. EVERETT.

29, Bede Burn-road, Jarrow-on-Tyne,
April 12, 1920.

BRITISH IRON AND STEEL PRODUCTION.—Mr. M. S. Birkett, statistical officer of the National Federation of Iron and Steel Manufacturers states that exports were reduced from 5,049,000 tons in 1913, to 1,618,000 tons in 1918, in order to secure an adequate supply of munitions of war; in the latter year more pig iron was converted into steel, and in steel manufacture pig iron was saved by an increased utilisation of scrap. The highest figure of steel production in the United Kingdom before the war was that for 1914, namely, 7,664,000 tons. In 1917, the production was 9,716,000 tons, and a furnace capacity for 12,000,000 tons had been provided for.

MEASUREMENT OF VERY SHORT TIME INTERVALS.—As early as 1876 Sabine proposed to utilise the partial discharge of a condenser through a resistance for the determination of time intervals such as ballistic calculations involve, and various arrangements for this purpose have been devised since. When a condenser of capacity C and resistance R is given an initial charge Q_0, and the charge Q remaining after an interval τ is measured by means of a ballistic galvanometer, the interval τ can be deduced from $\tau = C R \log_e (Q_0/Q)$. If E_0 and E signify the original and the remaining potentials, the similar equation will also hold: $\tau = C R \log_e (E_0/E)$; this latter method requires the use of electrometers. In the modification of the first method described by Paul E. Klopsteg in the *Physical Review* of January last the ballistic galvanometer is joined to a known potential difference nearly of the value to be measured, and the small throw of the instrument observed therefore merely measures the small correction to be applied to a fairly well-determined quantity. Thus intervals of 250 microseconds (1 microsecond = 10^{-6} seconds) determined by a Helmholtz pendulum, could be measured within 0·15 per cent. and intervals of 1 microsecond be estimated. The rather complicated device practically consists of a switch which when thrown over by the make or break of a circuit (by the projectile breaking a wire, for instance), deflects the ballistic galvanometer to an amount indicating the time interval. In trying the device on rifle bullets, it was found that bullet-speeds of 900 metres per second could be measured between two points only 20cm. apart. When it was attempted, however, to determine the rate at which the detonation proceeds along a stick of dynamite, divided into sections of 100 cm., sufficiently concordant results were not obtained, apparently because the explosion caused so intense an ionisation that the measuring current leaked across the wire gap.

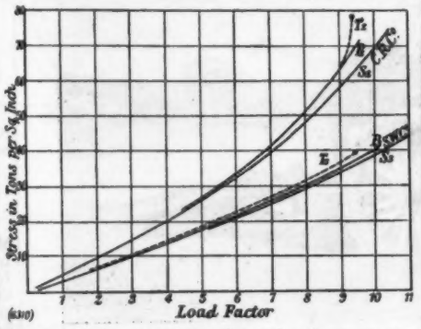
"THE DEVELOPMENT OF METAL CONSTRUCTION IN AIRCRAFT."

TO THE EDITOR OF ENGINEERING.

SIR,—Having been in touch with the so-called development of metal construction during the past two years, I have read the correspondence in your columns, on Major Nicholson's paper, with more than passing interest.

I was glad to see Mr. Naylor's valuable contribution, as I, too, had come to the conclusion that there must be some error in Mr. Pippard's formula; but, both these gentlemen seem to misunderstand Major Nicholson's curve L in his Fig. 25, which is not supposed to represent the stress-load factor characteristic of any specimen, as the other similar curves do, but rather, the locus of the maximum stresses, reached *at failure*, and obtained from numerous experimental results.

My main object in writing, however, is to point out that the use of a formula of the Perry form such as Mr. Naylor's (3) is justifiable in this case, and also



(Fig. 24)

gives extremely accurate results, and, owing to its comparative simplicity, is the most useful and interesting formula to engineers.

By applying the formulæ (3) and (5) given by Mr. Naylor the following total stresses are obtained for the given values of P in tons, in the case of two of the specimens illustrated by Major Nicholson's Fig. 24:—

	P.	(3)	(5)
Cycle Rim specimen	1·0	12·22	12·21
	2·0	27·83	27·92
	3·0	49·86	50·00
	3·5	65·10	65·21
	P.	(3)	(5)
Steel Wing Co.'s specimen	1·0	8·65	8·65
	2·0	18·35	18·36
	3·0	29·52	29·54
	3·5	35·87	35·91

It will be seen that the differences in the results are to all practical purposes negligible, as previously suggested.

In the diagram I have replotted, Fig. 24, showing the interesting, and in one case extraordinary results obtained by using either of these formulæ, which are represented by the additional curves P2 and P3.

From this diagram, any one who has carefully read Major Nicholson's paper, will no doubt be able to compare the two specimens further, to appreciate the excellent design of web in the one case, and to realise the instability inherent in that of the other.

Yours faithfully,

B. A. DUNCAN.

Bramley, Hook-road, Surbiton, April 13, 1920.

TO THE EDITOR OF ENGINEERING.

SIR,—I must thank Mr. Naylor for pointing out a slip in the formula which I quoted in my last letter. I agree that his No. 6 is the correct form. This will mean that the curve which I gave requires modification, and it will not run so closely to the actual test curve as shown.

The point which I really wished to make, however, and which I am glad to see is accorded both by Professor Lea and Mr. Naylor, is that the Perry approximation should not be used for the case now under discussion. Of course, I agree with Mr. Naylor that until premature secondary failure has been eliminated it is not to be expected that test and calculated stress figures will coincide, and until such a stage of design has been reached the method of comparison adopted has little significance.

The question of developing metal construction is an extremely important one from the standpoint of commercial aviation, and it is to be hoped that the very excellent work which has already been done by such capable experimenters will be continued and not allowed to fall through now that there is no longer the same urgent need for aircraft as obtained during the war.

Yours faithfully,

A. J. SUTTON PIPPARD.

Gwydir Chambers, 104, High Holborn, London, W.C. 1,
April 13, 1920.

THE WIRELESS SOCIETY OF LONDON.—At the last meeting of this society, which took place on March 27, a paper was read by Captain L. A. T. Broadwood, entitled "Harmonics in Continuous Wave Transactions." The next meeting of the society will take place on April 30, at 6 p.m., at the Institution of Civil Engineers, when a paper will be given by Major Basil Binyon, O.B.E., on a wireless "Call" device. The paper will be illustrated by experiments, and Major Binyon will show the device in question, of which he is the inventor.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Loss to Steel Trade.—The Sheffield steel trade has lost one of its best-known members by the death, on Tuesday, of Sir Charles Allen, V.D., chairman of Messrs. Henry Bessemer and Co., Limited. Sir Charles' father, Mr. W. D. Allen, founded the firm, and perfected the famous steel-making process invented by his brother-in-law, Sir Henry Bessemer.

Iron and Steel Institute.—Sheffield has been chosen as the venue for a portion of the annual spring meeting of this organisation. Opening in London, on May 6 and 7, the proceedings will then be adjourned for a week till the following Friday, May 14, when the final session will be held in the Mappin Hall of the Sheffield University, Applied Science Department. Sheffield has a special interest in the London meetings, in that Mr. Harry Brearley, the inventor of rustless or stainless steel, is to receive the Bessemer medal for services in connection with iron and steel research.

Continental Reconstruction.—The diminishing value of the franc and the lira is reacting with serious effect on French and Italian purchases of steel and engineering products. Requirements, particularly in France, are heavy, and under more normal conditions deliveries from South Yorkshire would be relatively large. Unfortunately, neither France nor Italy can afford to provide for anything like the whole of their needs, and in some cases contract bookings are being cancelled. A hundred tons of acid steel for which France paid 16,300 francs before the war, would now cost her 150,000 francs.

Iron and Steel.—Full activity, expanding in the more prosperous sections to marked pressure, is the general rule in the South Yorkshire staple trades. Industries developed during the war are experiencing such a wide demand that makers have temporarily closed their order books and suspended quotations. This applies specially to bright rolled bars and strip, now sought in large quantities by exporters and home manufacturers, chiefly for the construction of sporting guns and rifles. It is also impossible at the moment to place new orders for plates and sheets. Makers of mild steel are booked up for months ahead at high prices, and have no difficulty in securing substantial premiums on current quotations for special deliveries. The same applies to all kinds of steel billets, the scarcity of which is one of the most serious factors in hampering manufacture. The improvement in the high-speed steel trade, and particularly in export business, has brought renewed prosperity to the market for steel-making alloys. The tungsten works, which have experienced a rather depressing period while steel makers have been working on war stocks, are now booking orders freely. The bulk of them are disposing of their full output, and are sending old-standing stocks to United States manufacturers.

South Yorkshire Coal Trade.—The interruption in production at the pits during the holiday period is seriously reflected at iron and steel works, where, in many cases, manufacturers are drawing on emergency supplies to maintain current services. The fact that railway companies have secured substantial stocks, however, enables collieries to apportion a larger share of the output for manufacturing purposes. Though the pressure for house coal for current consumption is not so large, householders show anxiety to keep reasonable supplies in hand against emergency. There is a marked scarcity of all kinds of slacks. Contract commitments are in arrear. Coke is quoted on rail at ovens at 58*s.* 6*d.* per ton. The demand for blast-furnace coke is more than equal to the supply. Quotations:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Derbyshire best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; rough slacks, 24*s.* to 25*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The scarcity of Cleveland pig-iron, though hardly so acute as it has been is still very marked, and prevents business on anything like an extensive scale. Home and foreign inquiry is large, though pressure to obtain iron for certain quarters abroad is much less pronounced, some foreign buyers considering prices prohibitive. This, however, does not in the least disquiet makers, as they can readily dispose of the whole of their output to home customers. Prices are unaltered, but makers are once more showing marked disposition to advance rates, and higher quotations next month would cause no surprise. For home consumption, No. 1 Cleveland pig-iron is 212*s.* 6*d.*, and No. 3, as well as the commoner kinds, is 200*s.*; while for export to France, Belgium and Italy the former is 217*s.* 6*d.* and the latter are 205*s.*

Hematite Iron.—Nothing new of moment is ascertainable concerning East Coast hematite. Producers are so fully sold that they are indifferent to new business, and merchants have not a great deal of iron to offer, so that there is little business passing. No. 1 is 262*s.* 6*d.*, and mixed Nos. are 260*s.* for home purposes; and for shipment to France, Belgium and Italy, No. 2 is 267*s.* 6*d.* and mixed Nos. are 262*s.* 6*d.*

Foreign Ore.—There is an unsteady feeling in foreign ore, and it is very difficult to fix prices definitely. Sellers continue to take a very firm stand, and confidently

anticipate heavy business at high rates, but with freights falling—a steamer having been fixed at 34*s.* Bilbao-Middlesbrough—consumers are holding off the market in the hope and belief that they will be able to buy on better terms than are now offered.

Coke.—Coke keeps scarce and stiff. Medium blast-furnace quality is 55*s.* 6*d.* at the ovens, and low phosphorus kind is 58*s.* at the ovens. Foundry coke is 63*s.* for home purposes.

Manufactured Iron and Steel.—Little new was ascertainable concerning finished iron and steel. Prices, all round, were very strong, and there was plenty of business offering, but most manufacturers were too full of work to entertain further orders. Common iron bars were 26*l.*; best bars, 28*l.*; steel ship, bridge and tank plates, 22*l.*; steel angles, 21*l.* 10*s.*; rivets, 33*l.*; steel boiler plates, 28*l.* 10*s.*; steel joists, 21*l.* 10*s.*; steel strip, 27*l.* 10*s.*; steel hoops, 27*l.* 10*s.*; soft steel billets, 22*l.* 10*s.*; hard steel billets, 23*l.* 10*s.*; heavy steel rails, 21*l.*; fish-plates and sleepers, 26*l.*; black sheets, 45*l.*; and corrugated galvanised sheets, 56*l.*

Ironstone Miners' Wages.—In accordance with the ascertainment of the selling price of Cleveland pig-iron for the first quarter of the year, Cleveland ironstone miners' wages are increased by 21·4 per cent., which is much below the advance sought on national lines by the Miners' Federation of which the Cleveland miners and limestone quarrymen are members. The Cleveland mine owners, and men's representatives met at Middlesbrough this week and had several matters under consideration. The meeting was adjourned until after the miners' conference.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The position of things in the Scotch steel trade is practically unchanged as regards demand at any rate, and this even despite the ever-rising tendency of prices. Last week an advance was noted in black steel sheets, and now a further rise falls to be reported in plates, angles, &c. These latter were raised by the Scottish steelmakers for all deliveries on and after the 9th inst., and the new rates are as follow:—Ship plates, ¼ in. and up, 25*l.* per ton; under ¼ in. down to and including $\frac{3}{16}$ in., 30*l.* 10*s.* per ton; under $\frac{3}{16}$ in. down to and including ⅛ in., 32*l.* 10*s.* per ton; angles, &c., 24*l.* 10*s.* per ton; and boiler plates, 29*l.* 10*s.* per ton. The quotations are all net basis prices and are subject to certain extras for deliveries, and are for home consumption only. Buyers cannot get enough material to satisfy their needs and keep up a constant pressure for deliveries, so urgent is the local demand that the prospect of shipments abroad seems further off than ever. Foreign buyers nevertheless keep sending forward inquiries with some regularity in the hope of occasionally picking up an odd lot. Plate mills continue to run steadily, and the output gets very quickly absorbed, while the same may be said of structural sections which are in large request. Makers of black steel sheets, unable to keep pace with the demand are still declining to book forward lots, as their orders already on hand mean their whole output for months to come, and the working off of arrears is rather a slow process. Galvanised sheets are very active. Overall the steel trade is exceedingly active, and no advance in prices seems to cause any check to business.

Malleable Iron Trade.—The prevailing conditions in the West of Scotland malleable iron trade are unaltered, and great activity prevails at all the works. Orders are generally taken in turn and consumers are all so eager for supplies that even small deliveries are accepted without demur. The high level of prices has failed to ease the position, which would seem to get stronger daily, and "crown" bars are called 26*l.* per ton for home delivery.

Scotch Pig-Iron Trade.—A strong tone continues in the pig-iron trade of Scotland, and both foundry iron and hematite are as difficult to obtain as ever they were. The output from the furnaces is not nearly enough at present to meet the heavy demand, and consumers have still to be satisfied with a portion of their requirements to keep them moving. Of course, the prevailing home conditions have meant the cutting down of the export trade, and only a few small lots have lately been shipped abroad. Raw material is very scarce, and is high in price, and naturally the Scotch pig-iron quotations are exceedingly firm. Hematite is in great demand by the steelmakers, who are getting through large quantities.

Locomotives.—Reference was recently made to the manufacture of locomotives by Messrs. William Beardmore and Co., Limited, at Dalmuir, and now that firm has booked a contract for 90 passenger locomotives for the London and North-Western Railway Company. These will be of the "Prince of Wales" Class, having six coupled wheels in addition to a four-wheeled bogie.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Markets.—Business on the coal markets has been held up during the past week by a suspension of loading operations at Swansea and Port Talbot, as the result of a strike on the part of the trimmers at the former port and the tippers at the latter. On Monday the crane drivers at Barry also ceased work in connection with a claim for increased wages. All three strikes were ended yesterday and work resumed. In the case of the Swansea stoppage the coal foremen have agreed to the principle of individual employment from exporters as from May 8, and in the meantime the pooling system is to remain in force pending negotiations between the employers and the men. The Port Talbot tippers have resumed work under protest and passed a resolution to the effect that a higher authority than the local Trimming Board should decide the question as to whether tippers and discharge men should have preference when employment was given to additional coal trimmers. The Barry men have returned to work with an increase of 5*s.* per week pending a national settlement of the wages question. As was expected the South Wales miners have overwhelmingly balloted in favour of a strike to support their original wages claim, but it is anticipated that the votes in the other coalfields will neutralise the Welsh ballot and that the two-thirds majority, required to authorise a strike, will not be forthcoming, and that therefore the Government offer of a flat rate of 2*s.* per shift with an increase of 20 per cent. will be accepted. The South Wales miners have decided to tender 14 days' notice to terminate contracts from the 19th inst. in support of the grievances of the miners at the Nine Mile Point colliery in regard to the payment of the minimum wage to two men. Unless a settlement is reached, and so far the owners have refused to consider the matter, until the men resume work, there is a prospect of the whole of the coalfield becoming idle. In the circumstances releases for export continue to be very sparingly granted, and many ships are held up waiting cargoes. In one case a steamer of 2,000 tons has been waiting at Barry since February last for the release of a cargo for Portugal and in another a steamer of 3,000 tons has been waiting at Cardiff for three weeks for a cargo for Marseilles. The local docks are full of tonnage and, in addition, there is a considerable fleet in the roads waiting orders. Exports of coal abroad from South Wales last week at 191,445 tons, were the smallest for any single week in the current year and compared with the preceding week showed a decrease of 16,000 tons. Cardiff's total amounted to 122,758 tons, Swansea's 29,115 tons, Newport's 34,357 tons, and Port Talbot's to only 5,215 tons. Of the total shipments 99,231 tons, which is the smallest weekly quantity this year, was sent to France, 31,822 tons to Italy and 10,011 tons to British coaling depots.

Cardiff as Ship-Owning Centre.—A return compiled by the Cardiff District Shipping Federation shows that there are 113 Cardiff shipowning companies controlling 379 vessels of an approximate deadweight of over 1,500,000 tons representing a value estimated at 30*l.* per ton, of over 45,000,000*l.* The new list, compared with that of twelve months ago, shows an increase of 56 companies and 166 vessels.

PERSONAL.—Messrs. Ricardo and Co., Engineers, Limited, 21, Suffolk-street, Pall Mall, S.W. 1, inform us that their former name, "Engine Patents, Limited," was only registered as a temporary name; owing to their extensive connection with Government Departments during the war, some difficulty existed in changing it until they had fully emerged into peace conditions. They have taken the opportunity to effect the change co-incident with the full establishment of their experimental Research Department at Shoreham.—Messrs. Brunton, Musselburgh, have entered into an arrangement with Messrs. John Ackland and Co., Limited, Gracechurch Buildings, E.C. 3, under which large stocks of bright drawn free-cutting mild steel bars of their manufacture will be available for immediate delivery from stock to consumers in London and the South of England.

CONCRETE AGGREGATES.—The Concrete Institute has recently collected, in tabular form, a variety of useful information on the properties of aggregates available in different parts of the country. The collection of this information has been made possible by the co-operation of a number of county and borough engineers, who have furnished particulars upon forms provided by the Institute. By this means a large amount of valuable information has been made accessible to all who are interested in concrete work, and who wish to ascertain what aggregates are available in any particular district. The investigation is not yet completed, but the tabulated information at present collected is open for inspection, free of charge, on application to the Secretary of the Concrete Institute at Denison House, 296, Vauxhall Bridge-road, Westminster, S.W., from 11 to 12.30 and 2.30 to 4.30 (Saturdays, 10.30 to 12.30).

BUSINESS WITH INDIA AND CEYLON.—Mr. T. M. Ainscough, O.B.E., H.M. Senior Trade Commissioner in India, has recently arrived in this country. Mr. Ainscough will be pleased to meet manufacturers and merchants who wish to consult him in regard to steps to be taken for opening up trade with India and who are desirous of obtaining advice and information as to the state of trade in that country. Among the matters in regard to which he will be prepared to give information and advice are the general state of trade in India, appointment of agents, methods of marketing and distribution of goods, terms of payment, statistics of imports, rates of Customs duties, and general information as to the openings existing for British goods. It is to be understood that the Trade Commissioner is primarily interested in the imports from the United Kingdom into the territory in which he is stationed, and not in the exports from that Dominion to this country. Firms desirous of meeting Mr. Ainscough, should communicate without delay with the Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1.

NOTICES OF MEETINGS.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Friday, April 16, Meeting at Olympia at 5.30 p.m. Mr. H. Richardson, A.M.Inst.C.E., will present a paper on "Post-Bellum Road Restoration."

THE TECHNICAL INSPECTION ASSOCIATION.—Friday, April 16, at 7.30 p.m., at the Rooms of the Royal Society of Arts, John-street, Adelphi, a paper will be read by Mr. F. R. Wade, M.B.E., on the subject of "Labour Unrest—Its Causes and its Cure."

THE SURVEYORS' INSTITUTION.—Monday, April 19, at 8 p.m., Meeting in the Lecture Hall of the Institution, when a paper will be read, entitled "Some Problems Connected with Agricultural Policy," by Mr. Charles Browning Fisher, C.B.E., Member of Council.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—SCOTTISH CENTRE.—Monday, April 19, at 7.30 p.m., Meeting at the Royal Technical College, Glasgow, when Dr. W. H. Hatfield will read his paper entitled "The Most Suitable Steels for Automobile Parts."

THE ROYAL SOCIETY OF ARTS.—Monday, April 19, at 8 p.m. Cantor Lecture, "Aluminium and its Alloys," by Mr. Walter Rosenhain, B.A., D.Sc., F.R.S., Superintendent, Metallurgy Department, National Physical Laboratory (Lecture II). Wednesday, April 21, at 4.30 p.m. Ordinary Meeting, "The Commercial Future of Airships," by Air-Commodore Edward Maitland, C.M.G., D.S.O., A.F.C. The Marquis of Londonderry, K.G., M.V.O., Under-Secretary of State for Air, will preside.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, April 20, at 8 p.m., Meeting at the House of the Royal Society of Arts, John-street, Adelphi, London. A discussion on "The Lighting of Churches" will be opened by Mr. J. Darch.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, April 20, at 5.30 p.m., at the House of the Royal Society of Arts, John-street, Adelphi, W.C. 2. The following paper will be read: "Methods of Examination of Lubricating Oils," by Mr. G. F. Robertshaw. The chair will be taken by the president, Sir Frederick W. Black, K.C.B.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 20, at 5.30 p.m. The twenty-sixth "James Forrest" Lecture, "Coal Conservation in the United Kingdom," by Sir Dugald Clerk, K.B.E., D.Sc., F.R.S., M.Inst.C.E.

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, April 21, at 2.30 p.m., the third Annual Meeting in the Mappin Hall, Applied Science Department, The University, St. George's-square, Sheffield: Presidential Address. General discussion on Glass Refractories. The subject will be introduced by the following paper, "The Properties of British Fireclays and their Suitability for Use as Glass Refractories," Part I, by Edith M. Firth, B.Sc., Mr. F. W. Hodkin, B.Sc., and Mr. W. E. S. Turner, D.Sc. Second Annual Dinner at the Royal Victoria Station Hotel (Great Central Railway), at 7 p.m. Thursday, April 22: The following excursions have been arranged by the courtesy of the respective directors—In the morning, to the works of Messrs. Steel, Peech and Tozer, Limited, The Ickles, Sheffield, where members will have an opportunity of inspecting an up-to-date producer plant and other furnaces; in the afternoon, to the works of Messrs. Rylands Glass and Engineering Company, Limited, Stairfoot, Barnsley. Details as to times will be announced at the meeting on Wednesday.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, April 21, at 5 p.m., at 70, Victoria-street, Westminster. Papers to be read: (1) "Royal Observatory, Greenwich: Polar Night-Sky Recorder"; (2) "Local Weather Conditions at Mullion, Cornwall," by Lieutenant N. L. Silvester, F.R.Met.Soc.; (3) "The Surrey Hailstorm of July 16, 1918," by Mr. J. Edmund Clark, B.Sc., F.R.Met.Soc.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.—Thursday, April 22, at 7.30 p.m., Engineering Lecture Theatre, Liverpool University, "The Sea Shore," by Mr. W. Rimmer Teare (Hon. Secretary, Liverpool Biological Society).

THE INSTITUTION OF CIVIL ENGINEERS—STUDENTS' SECTION.—Thursday, April 22, at 6 p.m. A paper on "Compression Refrigeration" will be read by Mr. C. M. Brain. The chair will be taken by Engineer Vice-Admiral Sir H. J. Oram.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, April 23, at 9 p.m., a discourse will be delivered by Sir Israel Gollancz. The subject is "Shakespeare's 'Shylock' and Scott's 'Isaac of York.'" Afternoon Lectures, at 3 p.m. Tuesday, April 20, Major G. W. C. Kaye, O.B.E., M.A., D.Sc., on "Recent Advances in X-Ray Work" (Lecture II); Thursday, April 22, Mr. Sydney Skinner, M.A., M.R.I., on "(2) The Tensile Strength of Liquids"; Saturday, April 24, Mr. W. H. Eccles, D.Sc., M.R.I., on "The Thermionic Vacuum Tube" (Lecture II).

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 23, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Lecturette, "Modern Developments in Motor Car Design," by Mr. R. S. Fox, M.A., A.M.I.M.E., Member.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, April 23, at 6 p.m., General Meeting at the Institution, Storey's Gate, St. James's Park, S.W. Papers: "On the Hardening of Screw-Gauges with the Least Distortion in Pitch" (referring to water hardening) and "On the Hardening of Screw Gauges with the Least Distortion in Pitch" (referring to oil hardening), by the late Mr. W. J. Lineham, of London, Member. (Revised by Mr. G. T. White, of the Goldsmiths' College, London).

18-IN. HIGH-SPEED SLIDING AND SURFACING LATHE.

CONSTRUCTED BY MESSRS. SIR W. G ARMSTRONG, WHITWORTH AND CO., LIMITED, ENGINEERS, MANCHESTER.

(*For Description, see Page* 513.)]

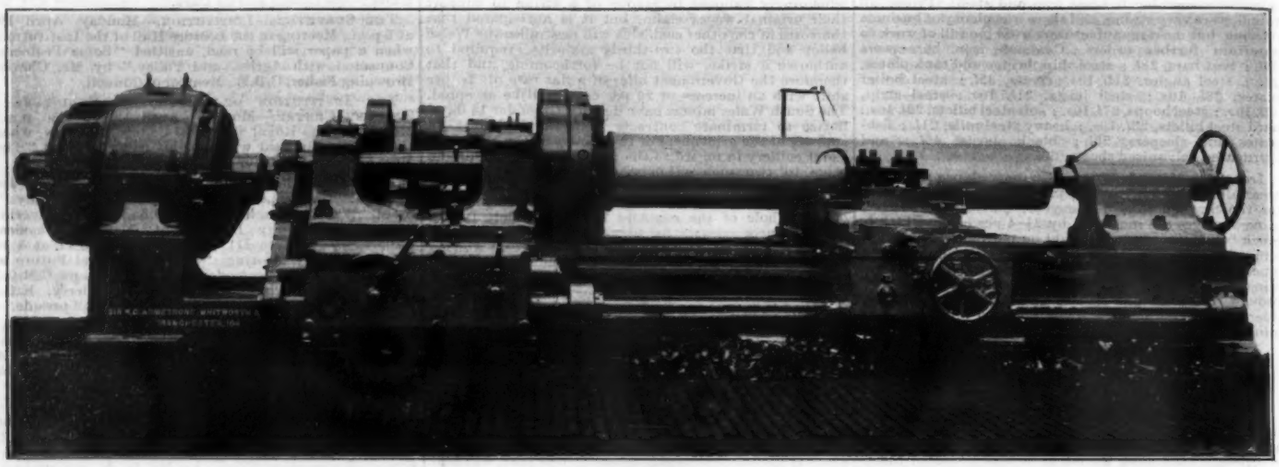


FIG. 1. GENERAL VIEW.

Fig. 2.

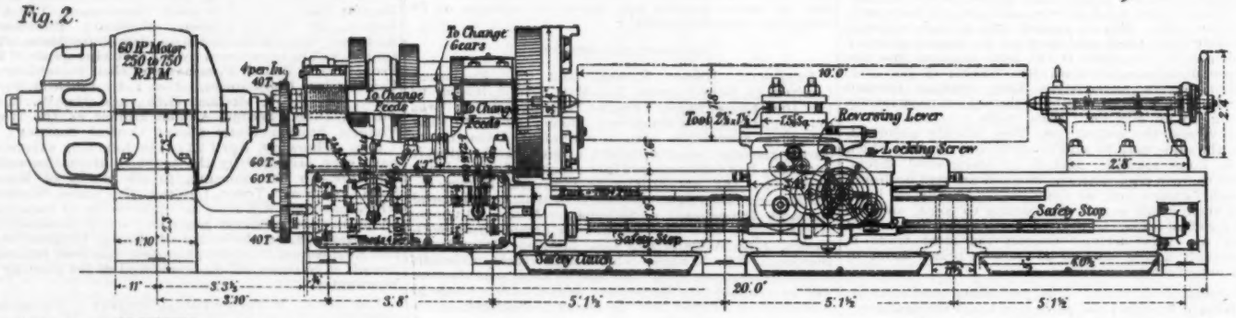


Fig. 3.

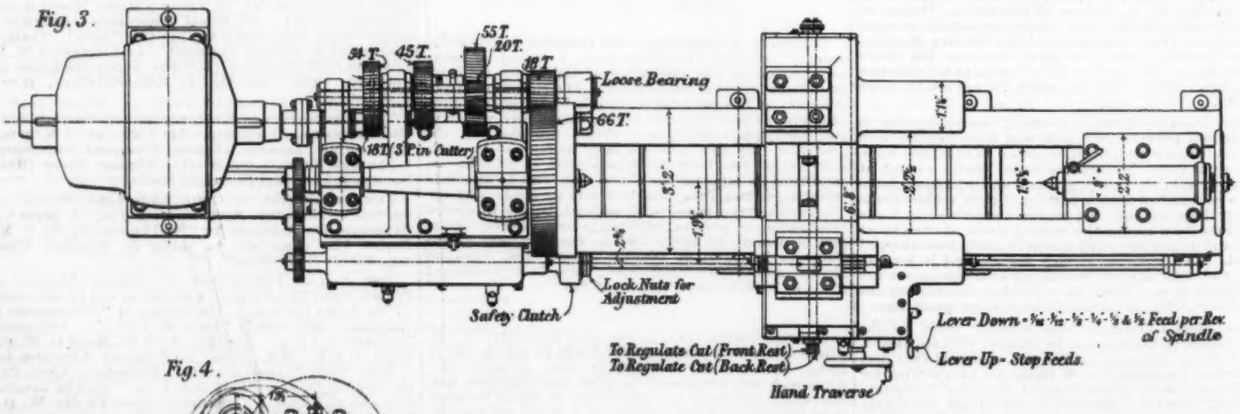


Fig. 4.

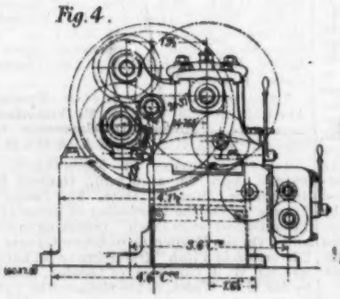


Fig. 5.

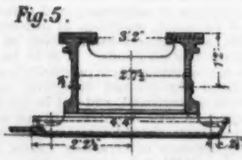


Fig. 6.

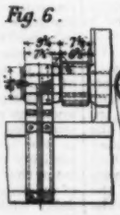
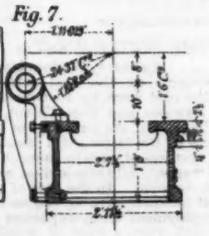


Fig. 7.

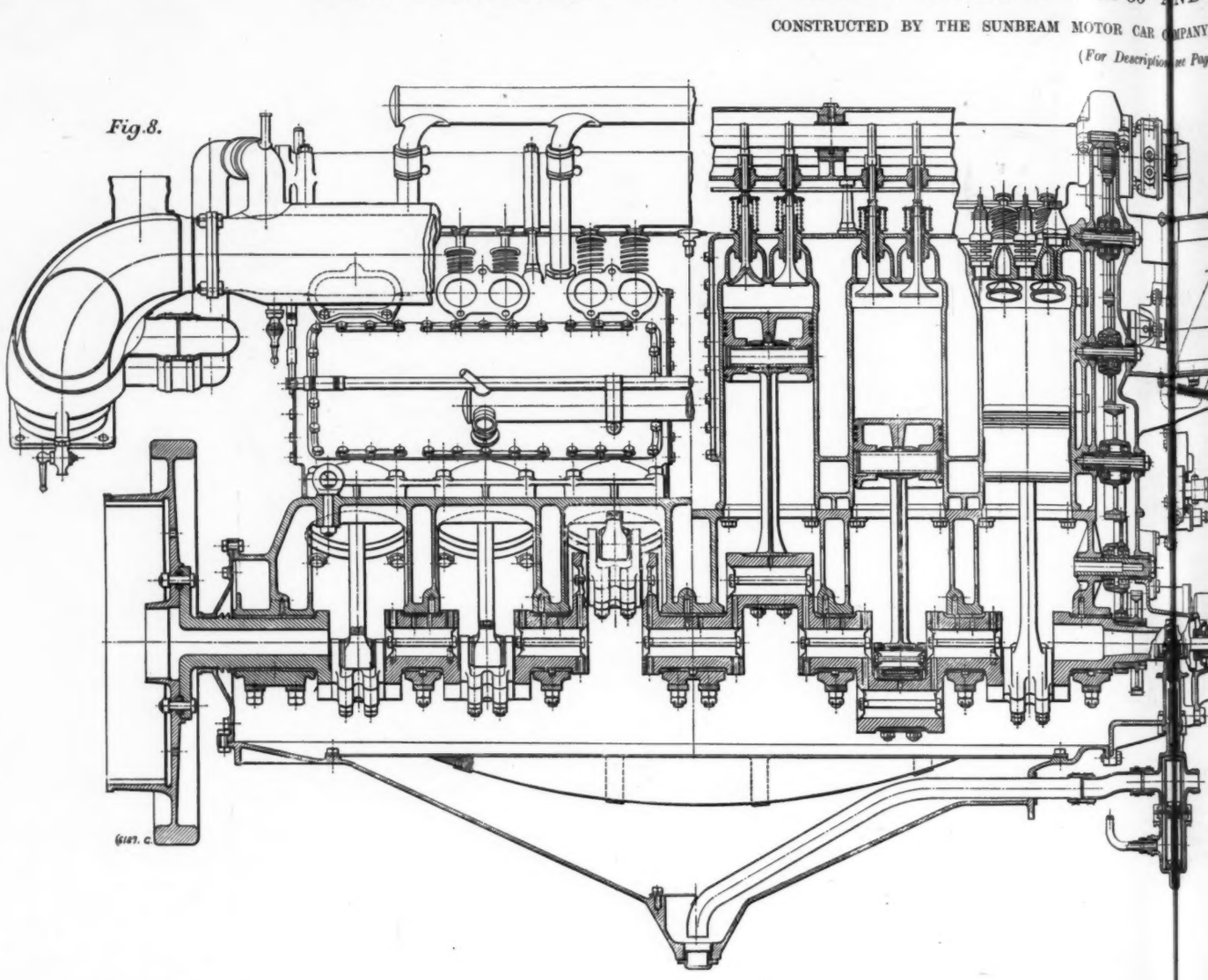


THE MACHINERY OF H.M. RIGID AIRSHIPS R 33 AND

CONSTRUCTED BY THE SUNBEAM MOTOR CAR COMPANY

(For Description see Page

Fig. 8.



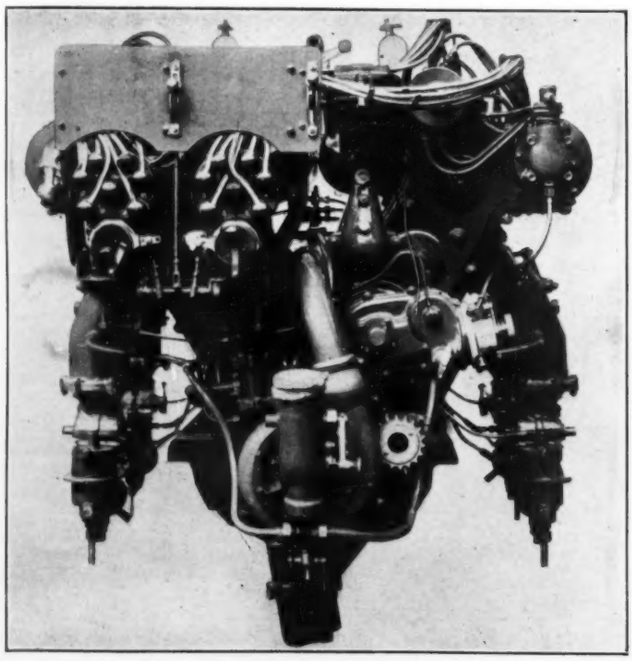


FIG. 10.

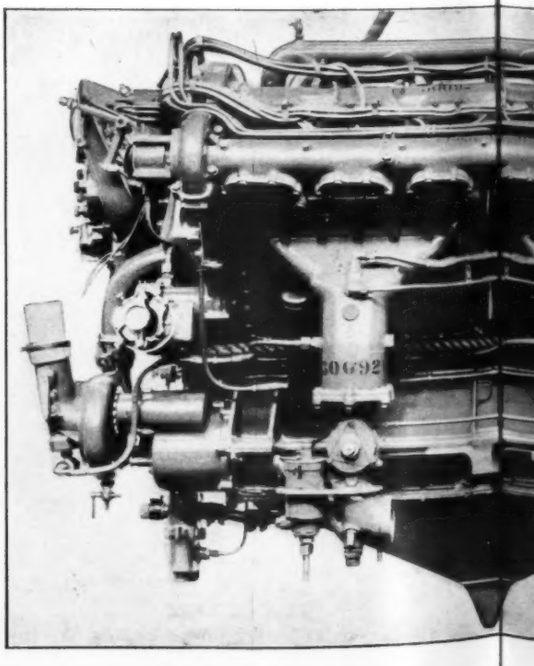


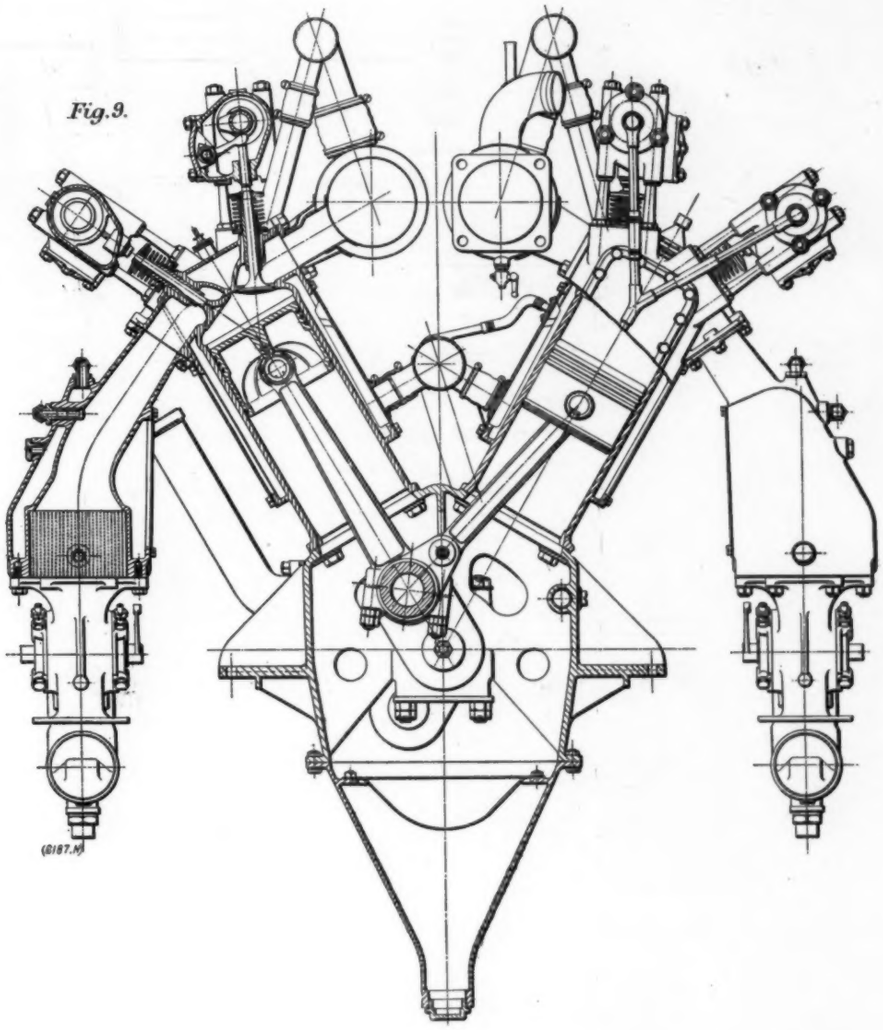
FIG. 11.

33 AND R 34; SUNBEAM-COATALEN "MAORI" ENGINE.

CAR COMPANY, LIMITED, ENGINEERS, WOLVERHAMPTON.

(For description see Page 504.)

Fig. 9.



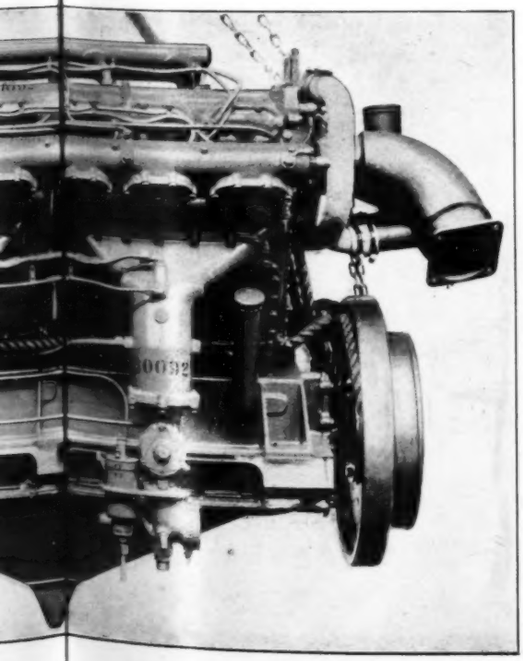


Fig. 11.

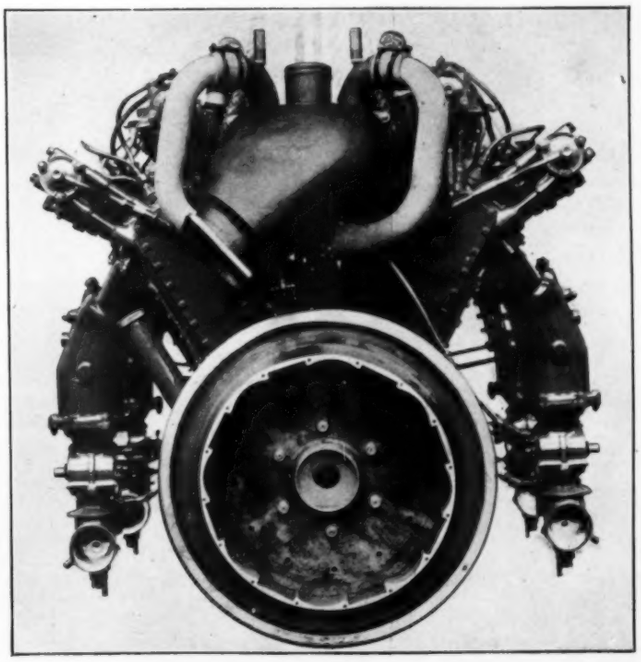


Fig. 12.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

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NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. So long as postal rates remain as at present there will be no increase in the price of copies sent by inland post, which will continue at 1s. 2d., post free.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 515.

ENGINEERING.

FRIDAY, APRIL 16, 1920.

DESIDERATA OF THE WORKER.

TWICE a day those who go down to their work in tubes and do their business in great cities, have the wonderful discomfort of modern urban travelling brought home to them in a very forceful way. Nothing that our traffic experts are able to do seems to alleviate this trouble, and we still patiently await effective developments. In the meantime trains are frightened out of stations by the hustlers hooter, and young men of an athletic turn keep themselves fit by practising scrum tactics on long-suffering passengers, compressing them into the cars by main force and slamming to the doors ere they bulge out again. The "train-packer" is now a regular American institution, and we have often wondered why our traffic people, usually so fertile of resource, do not raise the physical standard of their own door-jammers to a more efficient scale. Obviously a corps of big-chested six-foot men would be able to squeeze more passengers into each coach than the nimble light-weight skirmishers so often found on this duty in London. The passenger density could be considerably increased in this way to the "improvement" of the general situation; but perhaps some faintly lingering qualm of conscience still checks the traffic organisers in their evident endeavour to transform passengers into goods or cattle. The proverbial camel probably performs his feat of passing through the eye of the needle with less inconvenience and misery than his more sensitive occidental counterpart—the underground passenger—accomplishes his diurnal journeys into and out of the City. What the longed-for happy solution is to be, goodness alone knows; it will, we think have to be sought in a wider field than most people imagine.

The Underground Electric Railways, meanwhile, have schemes estimated at about £6,000,000 for tube extensions. Tapping new areas by these services will, of course, have the effect of aggravating the present crush. However, lest we should wince at the prospect of these further trials, after having patiently suffered for so long a time, Lord Ashfield attempts to revive our drooping spirits with an attractive picture—if he can find still further millions—of altogether new high-speed tubes, which are also adumbrated by the Advisory Committee on London Traffic. If realised in the happy future these certainly might be expected to afford some relief, but, as matters stand, neither Lord Ashfield nor anybody else can hold out the least prospect of such undertakings proving a financial success. Although the chairman of the Underground says that London can well afford to pay for them he has also admitted that the crucial point is how to raise the money. This point is also quite beyond the Advisory Committee. The investment of capital in London underground transit has lost whatever financial attraction it once had, and this being so, how can new and necessarily costly tubes be built?

The proposed readjustment of fares, although perfectly fair to the shareholders, will bring other and more complex difficulties in its train. For instance, as soon as it was suggested, we had labour stating that it would be made the pretext for renewed demands for increased wages. An authoritative statement was made lately at the House of Commons "that increased fares would disturb the whole question of labour in London, and the increase would have to come out of the employers, and that would put up the cost of everything." There is scarcely the shadow of a doubt that heavier travelling expenses would be made the peg on which to hang fresh demands for higher wages. Is it to be expected that such a chance would be allowed to slip? Maybe this, in the end, will prove a blessing in disguise, for it will provide added inducement for employers to remove their concerns to outside areas, and so bring about a much desired improvement in the life of the worker.

At a recent meeting in London, labour speakers rather sneered at firms who had removed to places like Aylesbury, holding that they had only done so because they could there secure cheaper labour. Other facilities being good, instead of being open to criticism, on this ground alone the action is praiseworthy. That labour is mainly cheaper because rents and rates are lower, travelling costs are cut out, and so on. This is so much clear gain to the country. Waste of the worker's time, energy and money, and waste of railway capital, are curtailed and the money thus saved is free for investment in productive industry. Transport, although one of our greatest industries, is not in itself productive, and is so only in so far as it is contributory to the compassing of productive activities after the most economical method. This fact is not always appreciated at its true value.

The Advisory Committee on London Traffic, in their proposals for a Traffic Board, recommend that such a board if constituted should, among other matters, study all town planning and housing schemes for consideration on traffic grounds. Traffic and housing problems are so intimately connected that, in our opinion, we ought actually to take matters still further. The Ministry of Transport would appear to be working in the right direction, for in the White Paper issued on Monday last it is stated that this Ministry should take a far-sighted view of the problem of congestion and "encourage self-contained industrial centres away from the large congested areas of our present large towns." This is to be done in co-operation with the Ministry of Health.

Consider for a moment what happens when a slum area is cleared in the East end of London. What is the immediate effect? Population is displaced permanently, because re-building is only sanctioned for a lower density per unit of area. The unhoused people may overcrowd for a while the neighbouring slums, but ultimately the movement must be outwards. There they may find accommodation in the jerry-built villas of speculators, or, as is preferable, in suburban estates developed on definite lines by more responsible bodies. They now have to travel in to work in their old neighbourhood by train or 'bus, and go to swell the already excessive crowds making use of these facilities. If, in the slum clearance and re-building, sites are reserved and ultimately leased for factories not in that district before, the situation becomes exaggerated, for then, not only the original crowd, but fresh workers have to be carried daily to that point. At the present time two London authorities are developing estates on the east side of the Metropolitan area, which, together, may be expected roughly to provide something in the order of 26,000 new houses. Supposing these to be inhabited by people from former overcrowded areas in London, and taking, for the sake of argument, two wage-earners per house requiring transport to their office or factory, about 70 extra trains will be required in, and the same number out of, London daily as a result of removing this population from the inner areas. This further congestion of an already overtaxed transport system can only be avoided in two ways. Although strictly, perhaps, outside our regular field, engineers as employers are so largely interested in the question of industrial

housing that we venture to consider them briefly.

The first has been suggested by Sir Martin Conway, to whom great heights are naturally commonplace. He suggests housing the people near the centre of things in skyscrapers 40 stories high. Unfortunately skyscrapers, even when let at exorbitant rates for business purposes, scarcely pay. In the United States they are said to bring a return of about 2 per cent. on capital. Rented for residential uses they could not possibly do so well. Even the much more modest modern London tenement block is said to have cost about 100*l.* per room to build before the war, compared with something like £30–£40 per room for construction at Letchworth at that time. From the financial point of view the skyscraper idea has little to recommend it, while the general amenities of life cannot be developed in connection with it to nearly the same extent as in a cottage scheme. The second solution is to induce a corresponding number of factories to the new outside sites at the same time as the population. The workers from these areas would then be saved their journey to town. This is the idea of the "Satellite" town of our reformers which, from the view of healthy living, and no less because it will go some way towards solving our traffic difficulties, deserves every encouragement. But, for its satisfactory development it requires coordination in town planning on lines which reach further than anything at present generally accepted as desirable, by an authority with a sufficiently extended horizon to consider the broad aspects of the complete problem.

Recently a report was published on the fitness of men of military age. To engineers this subject should be of great interest. This report showed in a convincing manner that such towns as Salford, Leeds, Sheffield, &c.—all engineering centres—had extremely bad records. Although in an examination of men engaged in engineering trades the "Grade I" percentage was fair, it must be remembered that most of the weakling offspring of "engineer" fathers drop out early in their apprenticeships, or are advisedly apprenticed to other trades. Only the so-called healthy would survive in the trade to the lower age covered by this examination. The general figures for engineering centres are thus a truer guide to the standard of fitness of men living in the ordinary conditions of the engineering and cognate industries. In all cases they are astonishingly low, and are no credit to so important and intelligent an industry as our profession represents.

We have just managed to pull through this war by roping in practically everything we had in the way of manhood, and a good deal of our womanhood. The next war may make still greater demands upon us, and we ought to leave nothing unattempted which can produce for us a fitter nation. The conditions of Letchworth may not be ideal or desirable of exact reproduction elsewhere, yet, when the infantile mortality for Letchworth is only 30 per 1,000, compared with a great deal over 100 for such engineering centres as Middlesbro', &c., surely there must be something worth considering in the difference of the conditions of existence between such places.

We have a glorious heritage. We have come out of the war with increased responsibilities to the world. Only by developing a virile nationality can we hope to discharge our trust. New and vast countries have come under our control, and our engineers and mechanics must be in the future as ubiquitous as in the past. To fulfil our destiny in these our home lands and in the wider spaces of the empire we need a fit and manly race whether our days be given either to peace or war. Let us then throw ourselves early into this great endeavour and do what we may, by improving living conditions of the workers, to wipe out the stain which the report indicates rests on this our industry.

MOTOR SPIRIT FROM COAL.

IN a leading article on page 85 *ante*, dealing mainly with the use of suction gas producers on motor vehicles, we expressed the view that benzole alone could not supply our future needs for motor spirit, but that it must be considered as a factor likely to affect the problem. The importance of the matter of rendering ourselves as far as possible independent of foreign sources of motor fuel is such that we make no apology for again referring to the subject, which we are led to do by a paper read before the Institution of Automobile Engineers by Mr. W. D. Pile, on Thursday, the 8th inst. The main conclusion that he arrives at is in substantial agreement with that expressed above, namely that the coking industry from which benzole is derived is not likely to develop rapidly enough to supply the ever increasing demands for motor spirit. Moreover, it must be remembered that the supply of motor fuel from this source will depend more upon the demand for the main products of coking than upon the need for the particular by-product to which we are referring. However, the possibilities of every substitute for petrol should be very carefully considered in view of the exhaustion of petroleum supplies in a comparatively short time, and particular attention should obviously be paid to motor fuels obtainable from home sources and from other sources within the Empire. We do not propose to deal here with the technical questions involved in the use of benzole in internal combustion engines, as this fuel is being satisfactorily and extensively employed as a substitute for petrol with little, if any, modification of existing designs; these questions are ably dealt with in the paper above referred to. It may, however, be interesting to consider the possibilities of producing a useful supply of motor fuel by the scientific and economical utilisation of coal in this country, and for this purpose we shall make use of data given in Mr. Pile's paper.

In this country, about one tenth of the total coal consumption, i.e., from 18,000,000 tons to 20,000,000 tons per annum, is used in the gas industry, which is the oldest, but not the largest, source of benzole. The manufacture of metallurgical coke in by-product recovery coke ovens forms a newer, but more important, source of supply, and a comparatively small quantity of benzole is obtained from tar-distilling plants. On the assumption that 18,000,000 tons of coal is used per annum in gas works, it is estimated that 30,000,000 gallons of crude benzole might be produced from this source if the whole of the gas were treated for the recovery of benzole. The yield of benzole per ton of coal carbonised in by-product recovery coke ovens is taken as 2·18 gallons, and, assuming that 20,000,000 tons of coal is used for coke manufacture, the possible yield from this source would be 43,600,000 gallons of crude benzole. Another 2,875,000 gallons might be produced from tar distillation, so that the total production possible from sources which have already been employed on a commercial scale amounts to 76,475,000 gallons per annum. The actual production of benzole in this country from all sources amounted to about 17,000,000 gallons per annum before the war, rising towards the end of the war period to about 42,000,000 gallons per annum. The annual production at the present time has probably fallen to somewhere about 22,000,000 gallons to 25,000,000 gallons, the latter figure being only 12½ per cent. of the quantity of motor spirit imported during 1919, viz., 200,332,618 gallons.

There are, however, other possibilities in connection with the manufacture of motor spirit from coal, and one of these was referred to in a paper read before the Cleveland Institution of Engineers in December last by Messrs. E. Bury and O. Ollander. It is estimated that from the coal carbonised in coke oven plants in 1918, 23,400,000 gallons of alcohol could be produced by the fixation of ethylene from coke oven gas. This is obviously a matter of extreme importance, when it is remembered that, according to Dr. Ormandy, a motor-car engine will run on a mixture of equal parts of alcohol and benzole, as satisfactorily, in every respect, as with petrol. It thus follows that, if all the gas works in the country were to instal plant for the recovery of ethylene, some 30,800,000 gallons of alcohol could be produced per annum in addition to the 30,000,000 gallons of benzole mentioned above. By a similar process about 32,000,000 gallons of alcohol could be produced each year from coke-oven plants, in addition to their 43,600,000 gallons of benzole. We should thus obtain 136,400,000 gallons of mixed motor spirit from these two sources alone, using only 38,000,000 tons of coal, which is the quantity now carbonised annually.

Yet another possibility of increasing our home-produced supply of motor spirit exists in the coal burned in domestic grates. In 1913 the consumption of coal for this purpose amounted to 35,000,000 tons. It has been stated that by low temperature carbonisation a ton of bituminous coal of average quantity can be made to yield 1,568 lb. of fuel suitable in every way for domestic use, in addition to 7,000 cub. ft. of gas, 20 lb. of ammonium sulphate, 16 gallons of burning and lubricating oils, and 3 gallons of refined motor spirit, the latter consisting partly of benzole and partly of constituents resembling petrol. Some 50,000,000 tons of coal would have to be carbonised annually to produce the weight of fuel required for domestic grates in 1913, and the yield of motor spirit from this would be 150,000,000 gallons. This, with 62,800,000 gallons of alcohol produced by gas works and coke oven plants, and 46,000,000 gallons of refined benzole which would be yielded by the 73,600,000 gallons of crude benzole obtained from the same sources, would give nearly 259,000,000 gallons of motor spirit per annum. There would, of course, be uses for the refined benzole in various industrial processes, so that the whole of the above quantity would not be available for use in motor car engines, but the remainder, it would seem, would comfortably cover our present needs for motor spirit.

The above is, of course, merely an interesting, and perhaps an instructive, speculation, the full realisation of which is, admittedly, extremely improbable. The all important questions of capital cost and working cost of plant, on which the selling price of the motor spirit would depend, have not been taken into consideration. At present the market price of home produced benzole is practically the same as that of imported petrol, whereas a fuel much cheaper than either is what is really required. It is significant that the production of benzole is now, only half what it was during the last year of the war, though there can be no question as to the present demand for motor spirit. The reason is possibly that it is not now profitable to work some of the smaller plants installed to supply war needs, which had to be met at all costs. The use of alcohol as a motor fuel again turns mainly on the question of the price at which it can be supplied, whether it is made by the ethylene process in this country or from vegetable products in other parts of the Empire. Very promising results have already been obtained with alcohol used in conjunction with ether and trimethylamine in a mixture known as "Natalite," which has already been referred to in our columns on page 150 *ante*. The main difficulty, we imagine, in connection with the production of motor spirit by the low temperature carbonisation of coal would be to induce the public generally to adopt the carbonised fuel, though the more enlightened members of the community would probably do so readily enough. Probably several years will elapse before the processes referred to have been developed sufficiently to have even a considerable effect upon the motor fuel question, and we greatly doubt that they will ever solve it entirely. Sooner or later, however, a substitute for petrol will have to be employed, and although benzole and alcohol seem likely to be the most important fuels of the future, the latter has the obvious advantage that it can be produced from the inexhaustible vegetable world. On the other hand, the possibility of using solid fuel in motor vehicles, although perhaps not of general application, must by no means be overlooked. By means of a suction gas producer a heavy lorry can be run with a fuel cost equivalent to petrol at 2·6*d.* per gallon,* a figure which cannot be approached by any form of liquid fuel with which we are acquainted.

THE BUILDING EXHIBITION AT OLYMPIA.

IN the years immediately preceding the war, the Building Exhibition had become a biennial function at Olympia. The last of the series was held in 1913, since when there has been a gap until the opening

* See page 85 *ante*.

of the present show on Saturday last. In view of the attention of which the building industry is now the object, and of the very real activity which that industry is displaying, the exhibition should fulfil a valuable purpose. Trade exhibitions, representing almost any industry, are at the present time likely to be of unusual service, but more perhaps to the building trade than any. In every industry there are manufacturers wishful to renew connections broken by the war and to bring forward the various new products to which the experiences of the last few years have caused them to turn their attention. These conditions apply to the building industry in common with others, but there is, in addition, a special feature in the building trade which makes an exhibition at the present time very desirable.

It is common knowledge that difficulties with labour are more acute in the building industry than in most. The feature hampering the trade more than any other is the refusal of the bricklayers to lay per day more than an official quota of bricks, which common experience of the past proves to be well below their capacity. This action of necessity drives builders to consider alternative methods of construction, and this exhibition serves to bring these various methods together and to display their relative merits to those interested. The last few years have seen great activity and progress in various methods of concrete building, a form of construction which no great while ago was far from popular with the public, and, indeed, was quite *démodé*, but is now accepted as fitting for domestic structures, equally with factory premises. Matters in this imperfect world sooner or later follow the line of least resistance, and the present action of the bricklayers' union is forcing adoption more and more of non-brick forms of construction. This movement is not a definitely active one with the idea of "dishing" the bricklayers; it is a natural movement of affairs which, given suitable conditions, can be controlled neither by bricklayers' unions nor any other body.

The modern forms of building, as developed more particularly for domestic structures, constitute one of the most important and interesting features of the present exhibition. The bringing together of examples of so many of these methods should be of great value to the industry. The methods divide themselves naturally into two classes—the construction of concrete blocks of various types for building purposes and the construction of monolithic walls *in situ*. This last method of building, in its broad sense, is not very new but, as the exhibition illustrates, a number of methods have recently been developed to make it more easily applicable to the small structure. We do not pretend to have made a complete statistical survey of the exhibition, but it may roughly be said that there are some 17 firms exhibiting concrete-block-making machines, and about half-a-dozen showing various special methods of monolithic construction. There are, in addition, a number of exhibits of various asbestos and cement composition slabs for building, special reinforcing methods, etc.

The various block-making machines differ in detail, but have a family resemblance. They are, in effect, forms of moulding machines. Some are very simple and consist, in brief, of a moulding box with hinged sides, arranged to fold downwards. Catches are arranged so that when the sides are up they lock. When they are in this position the box is filled with the concrete mixture from the open top and tamped by hand. The sides are then released and folded down, and the block is lifted away on a loose bottom plate, or pallet, on which it is formed. In some machines an ejector is provided, worked by a treadle, so that the block on its pallet may be more easily removed. In some cases a stripping plate is used. We think it is not called a stripping plate, but a builders' terminology appears to have been devised in connection with these machines which we confess is beyond us. We are incapable of regarding them as anything else than moulding machines.

As we have said above, in most cases the tamping of the wet concrete mixture is done by hand. In some machines, however, a spring mounted pressure plate is provided, which is operated by a heavy fly-wheel turned by hand. The plate is brought down with considerable pressure on to the open top of the filled box, and packs the material. An interesting machine of this class is shown by Messrs. W. Bayliss and Co., Limited, of 240–241, Dashwood-house, New Broad-street, E.C.2. This machine has a centrally-mounted pressure device, as described above, and a pair of horizontal rails, on which two boxes run on small wheels. The rails project on either side of the machine, and the two boxes run in opposite directions. A box is moved outward for removal of the formed block and refilling, while the second box is being pressed. The idea of the arrangement is to obtain a greater output per man, as one operator is continually attending to the pressure wheel, while two others move and fill the boxes and remove the formed blocks. The use of the pressure plate method would appear to render the machines somewhat more suited for unskilled labour, as less reliance is placed on the hand tamping.

A pressure machine of somewhat similar type is also shown by Messrs. Winget, Limited, of The Cape, Warwick. In this case, however, a fixed box is used. The majority of the machines exhibited by Messrs. Winget are of the hand-tamping type. These machines, as we have so far described them, make blocks with smooth faces, but in many cases, indeed, we think in all, arrangements are made to give the blocks some type of formed front surface. An imitation of rough-dressed ashlar appears to be popular. This is simply carried out by utilizing a pallet, generally made of cast-iron, with the required formed surface, which is, of course, reproduced on the block. A number of the machines are so designed that several blocks may be made at one time. This is arranged for by providing one, or more, division plates which lie vertically along or across the box. After filling and tamping the plates are withdrawn from below through a stripping plate by a treadle-operated motion, and the individually formed blocks may then be removed in the ordinary way. In the machine exhibited by Messrs. R. H. Kirk and Co., of Collingwood-house, St. Peters, Newcastle-upon-Tyne, this method of inserting special formers in the moulding-box has been carried to a considerable length, and by means of the one machine, plain or faced blocks, coping, sills,, &c. may be formed. The machine is of the rock-over type, a swinging cover first being rotated over on to the filled box, and the box with its cover then being rotated back until the box is upside down. The motion is then reversed, and the box withdrawn from the moulded block, which remains behind on the cover.

Many of the machines are specially arranged for making cavity blocks. The form shown by the British Léan Company, Limited, of 11, Suffolk-street, Pall Mall, S.W.1, may be taken as an example. In this a special tamper is arranged above the moulding-box and supported on a spring suspension. Its purpose is to facilitate filling and tamping, since the blocks which are formed have three, or more, cavities and comparatively thin walls. The tamper has a parallel motion, and serves to pack the wet material into the comparatively complicated form rapidly and easily. The blocks are pushed out of the box, or die, by an ejector, after forming. In the case of the machines shown by Messrs. Vickers, Limited, of Broadway, Westminster, S.W.1, the blocks are formed with circular perforations, which are formed by rods lying horizontally across the box. The arrangement generally corresponds fairly closely with the simple arrangement of machine we first described, but with the addition of the circular rods. These have a horizontal motion controlled by a lever, and after the block is formed are withdrawn through the side of the box. The block is then ejected from below.

Among the simple methods of applying monolithic construction to small buildings, and avoiding the use of the ordinary form of shuttering, one of the most ingenious devices is that shown by The Climbing Steel Shuttering Company, of 515, Queen's-road, Sheffield. This consists of a pair of light shutters made of bolstered galvanised steel plates. The shutters are applied inside and outside the wall, and only one row of such shutters is required to build a wall of any height. Each pair of shutters is held apart the thickness of the wall by means of wires which pass through holes pierced in the upper and lower edges of the shutters. Assuming a pair of shutters in position at the bottom of a wall to be built, the material is filled in to their top edge. The lower wires are then cut, and the plates are rotated around their upper edges, on the upper wires as hinges, until they occupy a position vertically above that which they occupied before. The edges which were previously at the bottom, but have now come to the top, are then again linked together with wire and filling-in proceeds. This process is repeated until the wall has reached the desired height.

A quite different type of appliance is that shown by Messrs. Concrete Dwellings, Limited, of 5 and 6, Great Winchester-street, E.C.2. This consists of a travelling-box on rollers which sits on the wall being built. In any position it is filled with the unset concrete, and then is moved forward to a new position for the next section. One roller of the box travels on the low-level above which the box is building, and the other on the higher level to which the filling of the box builds up. The box has a central partition, and forms a hollow wall. In all methods of this kind, as in the hinged shutter form of construction described above, it is claimed that unskilled labour can be used, but apparently skilled supervision would be necessary to ensure that the wall, travelling upwards in stages, travelled vertically. As a final matter this week we may refer to the cement-gun which is exhibited by The Ingersoll-Rand Company, of 165, Queen Victoria-street, E.C.4. This device, which will be familiar to the majority of our readers, delivers liquid concrete through a nozzle and enables, say, a ferro-concete partition to be very rapidly built-up.

(To be continued.)

NOTES.

Half-Watt Lamp Litigation.

The British Thomson-Houston Company, Limited, brought an action against the Corona Lamp Works, Limited, for an injunction to restrain the alleged infringement of their patent, which was granted in 1913, under number 10918, for "Improvements in incandescent lamps." The lamps in question are gas filled lamps and are popularly known as "half-watt" lamps. There were the usual defences, which ultimately were reduced to three, viz., want of invention or subject matter; insufficiency of description; and non-infringement. The first and third defences failed, but the second defence, want of sufficiency of description, was successful. The keynote of the invention was struck on the first pages of the specification which described it as "relating to a gas-filled lamp of higher efficiency than the best lamp on the market." The specification described the manufacture of a tungsten or other refractory metal gas-filled lamp in which the loss of energy, due to heat conduction and convection, was compensated by the employment of gas chemically inert and of relatively high pressure and a filament of large diameter or cross-section. The utilisation of this discovery to obtain high incandescence and high efficiency was an inventive step of a high order of merit as well as of great practical utility, and the patentees in effect claimed the sole right comprised in the principle. The objection on the ground of insufficiency of description turned on the use of the word "large," and the judge (Mr. Justice Sargant) came to the conclusion that the true view to take of the meaning of the word "large" was that it was not to be regarded absolutely in relation to mere diameter, but meant sufficiently large to take advantage of the new discovery as to convection or conduction losses and accordingly to produce such a combination that a much higher temperature and incandescence might be obtained with a commercial length of life. In seeking to prevent others from availing themselves to any great extent of the principle, the patentees failed to define or limit sufficiently the ambit of their claim. The method of giving effect to the discovery was one of degree, and the only change that was claimed was the change of degree of the thickness of the filament used. A degree of thickness that had to be ascertained not merely quantitatively but in relation to many

other factors was a poor indication to the world at large of that which the patentees were claiming to monopolise, because a lamp maker desirous of avoiding infringement would have to make elaborate experiments to ascertain whether his gas-filled lamp had such a degree of efficiency and length of life as to fall within the patent.

MINERAL RESOURCES OF THE EMPIRE.

Speaking at the twenty-eighth anniversary dinner of the Institution of Mining and Metallurgy, on Friday last, Sir Richard A. S. Redmayne, K.C.B., made a brief reference to the Imperial Mineral Resources Bureau, which has been formed by the Institution of Mining and Metallurgy, the Iron and Steel Institute and the Institute of Metals. The object of the Bureau, he said, was to constitute a clearing house of information in connection with the mineral industries of the Empire and of the world. One of its functions would be to issue data as to costs and trade statistics, and it was also intended to publish a digest of the mineral laws of the Empire. Its effect would be to form a kind of league of nations within the Empire, and by consolidating the different interests involved, to render the Empire self-supporting with regard to mineral supplies. In general it would serve as an instrument to bring producers and consumers together, and it would also assist the industry by calling attention to new uses which may be discovered for any particular metal. There is no doubt, as pointed out by Mr. Oliver Wethered, that an almost infinite field exists for the investment of capital in mining interests within the Empire, and although the conditions for capital in, say, Australia, are not perhaps ideal, they are certainly better than those now prevalent in Russia and Mexico; even in this country the possibilities are by no means exhausted. The first annual report of the Bureau has recently been issued, and the president of the Institution of Mining and Metallurgy, Mr. Hugh K. Picard, in congratulating Sir Richard Redmayne, who is chairman of the governors of the Bureau, on the work accomplished and the plans laid down, called attention to the need for financial assistance from the Government on a more generous scale. It is quite possible, as Mr. Picard mentioned, that, unless the Bureau is placed in a very strong position, it may do harm by causing other bodies to relax their efforts. This is certainly an important point, as there will undoubtedly be a tendency to leave matters, such as those above referred to, largely in the hands of the Bureau, and, unless the latter has ample resources to deal with them thoroughly, the resulting benefits to the industry may be less than would be the case if individual concerns merely watched their own interests.

OBTURATORS *versus* PISTON RINGS.

Experiences with air-cooled engines on aircraft led in some cases to the replacement of the ordinary piston rings by an obturator, which is essentially the equivalent in metal of the cup leather used for packing hydraulic cylinders. The air-cooled cylinders of rotary engines, it was found, suffered distortion when at work owing to the leading side of the cylinder being more effectually cooled than the trailing side. As a consequence, piston rings often failed to hold the pressure, satisfactorily. Any increase in their number would have involved a longer and heavier piston, and the obturator was introduced in consequence. This, as explained in an interesting and valuable paper by Mr. W. Fennell, M.I.E.E., which was read at a recent meeting of the Diesel Engine Users' Association, consisted of a flexible L-shaped ring forced against the cylinder wall by fluid pressure. At the outset the life was short, but improvements made at the works of "Engineering and Arc Lamps" increased the life from 10 hours to 60 hours, and in exceptional cases to 250 hours. Brass was the metal first employed, but a special phosphor-bronze is now used. The obturator was placed near the top of the piston, but being flexible and forced by the pressure into close contact with the relatively cool wall of the liner it did not burn. Nevertheless, it is now considered preferable to fix it some little distance below the piston head. As originally fitted the rings were split similarly to a piston ring, but a lap joint is now used, and with this, the obturator works well, even if the liner be worn out of truth. In consequence of the satisfactory behaviour of these obturators, Mr. Fennell determined to fit one to a three-cylinder Sulzer-Diesel engine rated at 140 h.p. The liners of this engine had worn badly, being far from circular and tapering to the extent of $\frac{1}{16}$ in. It was impossible under the conditions to obtain new liners, and piston rings failed so rapidly the engine could not be run save at a prohibitive cost. It was decided accordingly to fix the three top rings of the piston and to place an obturator in the fourth groove. After a run of 100 hours without loss or blowing by, the obturator was examined. The wear was less than 1 mil, and the engine was set to work again, without replacing it. This obturator lasted 380 hours and then failed, due to wear at the lap joint. Here the motion was considerable, owing to the taper of the liner. Further experiments showed that even with these badly-worn liners the obturator might be counted on to last 300 hours, which was longer than the piston rings would stand. Further tests are, Mr. Fennell stated, in progress, and they indicate that with the liners in proper condition the life of the obturator should be well over 1,000 hours.

THE COST OF AERIAL TRANSPORT.

Not the least of the many difficulties with which the inauguration of civil aerial transport schemes is attended, is the almost complete absence of data as to operating costs, depreciation, &c., without which it is impossible to form an accurate basis for the charges to be made. A useful addition to the available information on this subject was made by Capt. P. D. Acland in a paper read before the Royal Aeronautical Society last Wednesday evening. Capt. Acland considers the case of a service intended to carry a ton of goods daily each way between two points 300 miles apart, and assumes the use of moderate sized twin-engined machines of the Vickers-Vimy type, full particulars of which will be found on page 736 of our 107th volume. This machine, it may be mentioned, is actually capable of carrying a load of over 3,000 lb., but it was considered advisable to take the normal load as about 75 per cent. of the maximum, while to allow for head winds and other delays, the average speed is reckoned at 80 m.p.h., although the full speed is about 100 m.p.h. To maintain the service, six machines would be required—two flying, two standing by for emergencies, and two undergoing repairs. The capital cost of these would be about 125,300*l.*, including four spare engines, and 20 per cent. of the value of the machines and engines in spare parts, plant and equipment for terminal stations, road transport, wireless equipment and advertising. The above sum also includes an allowance of about 30,000*l.* reserved in cash for working capital. The actual flying time would be about $7\frac{1}{2}$ hours per diem, so that taking the working year as 300 days and allowing an additional 5 per cent. for running the engines and testing, gives 2,360 hours as the estimated time the engines would be working. The cost of petrol at 35 gallons per hour and at 4*s.* per gallon, comes out at 16,520*l.*, and oil, the consumption of which would be 2 gallons per hour, at 10*s.* per gallon, accounts for another 2,360*l.* Other items in the running costs are—staff, 8,820*l.*; repairs, renewals and upkeep, 13,600*l.*; depreciation, 38,100*l.*; insurance, 11,500*l.*, and sundry expenses, 3,000*l.* The total working cost would thus amount to 93,900*l.* per annum, and as the distance covered would be $80 \times 2{,}250 = 180{,}000$ miles, the cost comes out at 10*s.* 6*d.* per mile, or 10*s.* 6*d.* per ton-mile, since the load carried is 1 ton. Parcels could thus be conveyed at the net cost of 1*s.* 5*d.* per lb. for the whole distance of 300 miles, and, bearing in mind that this figure includes no allowance whatever for dividend on capital, the normal rate of 2*s.* 6*d.* per lb. charged by most operating companies seems by no means excessive. The main difficulty, apparently, would be to ensure a regular daily load in both directions. The carriage of mails seems, at the moment, to be the most likely proposition for meeting the difficulty, and if letters and packages intended for aerial mails could be posted, with additional stamps, anywhere within a certain radius of an air terminus, we have no doubt that large numbers of the public would avail themselves of the service.

THE JURISDICTION OF MUNITIONS TRIBUNALS.

An important judgment was given last week by Lord Sands, the Scottish judge of appeals from Munitions Tribunals, in the case of Robert Climie, of the Workers' Union, against the Singer Manufacturing Company, Limited, which may serve to remind the munitions tribunals that it is no part of their duty to decide what prescribed or substituted rates are applicable to particular classes of workers, but that on such questions arising in the course of proceedings before them it is their duty to report them to the Minister of Labour in order that he may take steps to have them settled. The Workers' Union were a party to an arbitration in January of last year with the Engineering and the National Employers' Federations, before the *interim* Court of Arbitration, in which the Union claimed certain advances for their female members employed in federated engineering shops, boiler shops and foundries. The Court of Arbitration awarded advances of 5*s.* per week to women and 2*s.* 6*d.* per week to young girls. The award did not apply originally to non-federated firms, but the Wages (Temporary Regulation) Act provided that where an award varying a rate was made the Minister of Labour might, on the advice of the Court of Arbitration, direct that it should apply to all workers to whom "the prescribed rate in question" was applicable—that is to say, when any class of workers had a prescribed rate and an award was made which varied that rate as regards some of the class of workers the Minister could direct that the award should apply to the whole class. Such an order was made, following upon the award in question. The Singer Company did not pay the advances, as they considered that the award, even as extended by the order, did not apply to their employees, and, as a result they were prosecuted before the Glasgow Munitions Tribunal by the Workers' Union, on behalf of about 400 of their female members who were employed in the company's works at Clydebank. The tribunal refused to report the question to the Minister of Labour, and decided that the company were liable to pay the advances. The company appealed, and Lord Sands quashed the tribunals' judgment and directed it to report the question to the Minister of Labour. Lord Sands pointed out that the Wages Act does not contemplate that questions of this kind should be determined by the tribunals, but provides, on the contrary, that whenever a question arises, in any proceedings before a tribunal, as to whether a prescribed or substituted rate applies to any particular class of workers, or as to what is the prescribed or substituted rate applicable to that class, the tribunal is bound, in terms of the Act, to report the question to the Minister of Labour. The company contended that the prescribed rates in the general engineering industry did not apply to them, because even if their work was to be regarded as engineering it was a special branch of engineering with rates of its own, and that therefore the award, which—even as extended by the Order—merely varied the prescribed rate for women in general engineering establishments, did not apply to them. Lord Sands, holding that this was just the kind of general question which ought to be referred to the Minister, said "I think that there is a reason underlying this rule. I do not think such general questions can be determined by definitions and dictionaries and the other *media* of construction adopted by lawyers. I think they are rather matters of industrial custom and understanding"; and he indicated that it was therefore more appropriate that they should be dealt with by the Minister of Labour or referred by the Minister to the Industrial Court.

FINSBURY TECHNICAL COLLEGE.—The Old Students' Association of Finsbury Technical College have sent us a copy of their magazine for the current month, the first issue since the war. A general meeting to adopt new rules for reorganising the association is to be held at the college on May 4, at 6.15 p.m., when all old students, both day and evening, are urged to be present. A conversazione is to be held at the college on Friday evening, April 30, to which all old students are welcome. A copy of the magazine will be sent to any old student upon a written application to the Hon. Secretary, Leonard Street, City-road, E.C.

LITERATURE.

General Conditions in Electrical and other Engineering Contracts. By WILLIAM SMITH KENNEDY, LL.B., Barrister-at-Law. With an Introduction by Sir ALEX. B. W. KENNEDY, LL.D., F.R.S., Past-President of the Institution of Civil Engineers. London: Sweet and Maxwell, Limited, 1920. [Price 12*s.* 6*d.* net.]

In an Introduction to this work, Sir Alexander B. W. Kennedy, Past-President of the Institution of Civil Engineers, expresses the opinion that the text of Contracts and Specifications affords "the very driest kind of reading imaginable," and with this view engineers generally will certainly agree. Even when keenly interested in the agreement, some effort is needed to struggle through the details, and few know with any degree of precision what they have undertaken or appreciate the consequences of a slight alteration in the wording. Hence it is convenient to construct a system of model clauses, which settle on general grounds the several responsibilities that attach to the employer, the supervising engineer, and the contractor, safeguarding the interests of each. Several corporate bodies have drafted such model schemes, applying to the operations with which they are more immediately connected, but the Institution of Electrical Engineers and the Royal Institute of British Architects, who are among the number who have attempted the work of codification, are concerned rather with special than general requirements. The author of the work now under notice seeks to widen the scheme and offers for acceptance, perhaps also for criticism, a series of clauses that will be generally available, by reason of their justice and freedom from ambiguity. By the addition of notes explaining the reasons for modifying adopted formulae, he demonstrates the pitfalls that await ignorant or careless acquiescence, and enables the layman to gain a clearer insight into the duties and relations existing between the contracting parties.

The relations between the engineer and the contractor are apt to be strained, and it is not unlikely that some friction will arise if the engineer regards himself solely as the servant of the employer, whose interests he is bound to uphold at all hazards. The position of the engineer as an intermediary is a delicate one, and the view the author takes, and one which is intelligible, is that the engineer should regard himself as a quasi-arbitrator standing between the contractor and employer, and required to weigh their respective claims. On no account will the author approve of any suggestion which may tend to lower the status of the engineer. He is undoubtedly right in refusing to accept a subordinate position for the engineer in regard to the contractor. Both the employer and the contractor should and will benefit by the existence of a competent impartial adviser, invested with sufficient authority and of sufficient high standing to impose his ideas on both sides and to modify the exorbitant claims of either.

Only in one place does there seem to be any possibility of conflict in the duties assigned to engineer and contractor respectively, or any fair grounds of complaint that the latter is treated with undue severity. This instance occurs in the important clause on "maintenance," by which it is stipulated that the contractor binds himself to be responsible for, and make good, replace, and repair all defects, faults or imperfections in the same due to workmanship or design." It is, of course, to the last word that any exception can be taken. Design is distinctly the function of the engineer. The contractor covenants to complete a paticular design, and frames his tender upon the information provided. He does not undertake, nor should he be required, to erect and provide a plant or installation different from that for which he has tendered. Such details as the strength of materials, the margin of safety, the competency of an arrangement or artifice to effect a definite purpose is essentially within the province of the engineer. To take a concrete example—the case of the disastrous failure of the bridge over the St. Lawrence river to fulfil its purpose, it would not have been either just or equitable to throw the burden of restoration entirely on the contractor, who was working under authoritative direction, and had no information that was not equally at the command of the engineer. But if the contractor had signed such a clause as here drafted, it would seem that he could have been held liable. It is true that Mr. Kennedy adds in his explanatory notes that the contractor is, of course, not responsible for the original design of the plant as a whole, but if this is the meaning and intention of the clause, the reservation should have been made clear and precise. Little protection or enlightenment is afforded by referring to another clause in which the contractor is held to have carefully examined the information provided and to have concurred "as a practical tradesman in the method and styles of construction to be adopted, and the sufficiency of the materials proposed to be used in the execution of the work." This clause may, if he has failed to protect himself adequately, press unduly heavily on a contractor, who should have accepted responsibilities in works involving unusual difficulty or as the outcome of untried experiments. For the author is able to quote the decisions of eminent judges, who assert that the contractor must fulfil his engagements or pay damages for failure in so doing, "although, in consequence of unforeseen events, the performance of the contract becomes unexpectedly burdensome, or even impossible." The author's comment on this decision of Mr. Justice Blackburn is, that if unforeseen circumstances do not void a contract, *a fortiori*, if the events are such "as might well have been anticipated by a contractor, who studied the specifications and drawings intelligently, he is bound to complete the contract according to them." Precisely, according to the specifications and drawings as originally supplied to him, and not according to other specifications which the engineer ought to have supplied, but did not. It is difficult to understand why only the contractor is expected to display an intelligence that the engineer has failed to exhibit. A further judgment by Lord Chelmsford is cited, but we respectfully submit that the short quotation is misleading. The judgment declares that to rely on the drawings and specifications supplied by the engineer was "a usage of blind confidence of the most unreasonable description." In what sense can it be said that to trust to the knowledge and decision of an eminent engineer is "most unreasonable." Possibly some material point in the evidence has not been reproduced.

The lay mind may find it hard to appreciate the fact that a contract whose fulfilment would involve an illegality is thereby null and void, while if a physical impossibility stands in the way the contract must nevertheless be carried out. The greater the difficulty in following the judgment of the courts, the greater the need of a book of this description in which an expert provides a clue through the maze of legal subtleties. Ignorance of the law is no excuse for disregarding it, and oftentimes the author points out that though the introduction of a particular provision in a clause apparently entails a hardship on the contractor, the latter would be no better off if such provision were omitted, because common law would enforce the obligation though it were not distinctly enjoined. It is well, too, that the contractor should be reminded of the full extent of his liabilities. To appeal continually to Statute law for the determination of rights is to invite trouble, just as to attempt to provide beforehand for all contingencies that can occur, is more likely to occasion than to avoid disputes.

We should like to submit another conundrum. What constitutes a "personal" contract? The point, though unsettled, is important, because personal contracts may not be assigned and contracts which are not personal may be. In the case of bankruptcy, or of death, grievous trouble may easily ensue. Under the ordinary definition, that a "personal" contract involves the "individual skill, competency, or other personal qualification," limited companies and corporate bodies are necessarily excluded. Since in large contracts, impersonal firms and companies are largely employed, another definition has been substituted in which the determining qualities are the "character, credit, and substance" of the agency with whom the contract is made. A limited company, selected on the ground of its "credit and substance," might therefore be held to have entered into, or be capable of entering into, a personal contract. The author admits that the point is arguable, but he is of opinion that the courts would not hold a contract with a limited company, or a firm of contractors to be "personal," and in that case any public company could sublet or assign a portion of the work to other firms. Hence the necessity of stating the exact conditions under which a contract may be sublet.

A clause which has given much trouble and discontent in the past is the so-called arbitration clause defining the position of the employer's engineer as arbitrator and the conditions under which an appeal from his decision is permissible. Two extreme views, the author states, have prevailed on those points in engineering circles, the supporters of the one claiming that the engineer is an autocrat whose authority is supreme, while the advocates of the other maintain that any of the decisions, however trivial, may be submitted to the arbitrament of an impartial outsider. Between these views so diametrically opposed, Mr. Kennedy has sought to find a formula that will satisfy both contestants. Broadly speaking, he would reconcile opposing interests by suggesting that the engineer's decision should be final concerning the quality of the work and of the material, "but that the question of monetary value of the work done should, in case of dispute be settled by an outside arbitrator." This suggested compromise has the approval of Sir Alexander Kennedy, and it will be generally admitted that while making some concession, it has the merit of recognising that in the conduct of the work the engineer is endowed with absolute authority. The precise points on which the engineer's ruling cannot be questioned are indicated in other clauses, which may make some of the phrases surplusage, but the delicate point lies in the possibility of the quality of the work and the "monetary value" reacting on each other.

The treatment of this particular clause may be used to indicate the general scheme of the work under review. In the first place, a clause is drafted in a form which in the opinion of the author could be fairly recommended to all the parties of the contract. Comments are then added giving the reasons for adopting the form chosen, and a comparison is made with the clauses adopted by other authorities, who have endeavoured to secure the attainment of a similar object. Where substantial differences are noticeable, the author defends his choice, and as the grounds for disagreement are often elaborated to considerable length, the comparison is highly instructive. The model forms of contract approved by the Institution of Electrical Engineers has been very carefully considered, and this scheme has been thought of sufficient importance to be reprinted in its entirety as an appendix. Of scarcely less value are the forms of contract issued by the London County Council, the War Office, and some of the railway companies. These have all been submitted to the test of experience, and perhaps are now accepted without much enquiry by the contracting parties, because long experience has taught each side what is expedient, if not what is lawful.

In conclusion, we may certainly endorse and emphasise the view expressed by Sir Alexander B. W. Kennedy, namely: "that both engineers and contractors have proved themselves, on the whole, sensible men, and have interpreted and worked on the conditions with a considerable amount of common-sense give and take . . . Mr. Kennedy has dealt with the whole matter in a clear and helpful fashion, which ought to be useful to all those—on both sides of the table—who have to do with the specifying, making, or carrying out of engineering contracts, for whatever class of work."

History of the Great War, based on Official Documents, by Direction of the Historical Section of the Committee of Imperial Defence. Naval Operations. Vol. I. *To the Battle of the Falklands, December, 1914.* By Sir JULIAN S. CORBETT. Longmans Green and Co. London: 1920. [Price with Maps in separate case 17*s.* 6*d.* net.]

As long ago as 1916, Mr. Asquith foresaw the necessity of providing an official history that should record the various aspects of the war, and promised to satisfy the demand that would naturally arise at the end of the conflict. The present work indicates the amount of progress

that has been made in fulfilment of that undertaking. It covers only a brief period as measured by time, and of the various phases of maritime activity that will have to be considered, Sir Julian Corbett has considered only the actual work of the Fleet and the causes, military or political, that have determined its operations. Able colleagues will deal with the effect of the war on sea-borne trade and the special part played by the mercantile marine. By this division of labour, the author hopes that four or possibly five volumes will be found sufficient to complete his share in the entire history. The plan is conceived, therefore, on wide lines, and this minuteness of detail is necessary to explain doubtful points, and to correct the misconceptions that have been accepted owing to the unsatisfactory nature of the information supplied to the public during active operations. In the course of the war, correspondents and publicists circulated information that was necessarily imperfect by reason of the limited areas that came under the observation of each. These partial views were rendered still more untrustworthy by the deletions of the Censor, warranted by the exigencies of the military situation. Since the armistice many authorities, who occupied responsible positions among the various belligerents, have issued descriptive and polemical works, in which they have sought to justify their action or to deprecate censure. These have proved scarcely more edifying, because a propagandist tendency has generally been apparent, and self-interest has prejudiced judgment. From the author, we may expect in this and the succeeding volumes, an impartial and authoritative contribution to the literature of the subject. He is free from the influences that have disfigured some of these recent productions. He is not interested in defending injured reputations, and there is no need to misrepresent or to suppress facts. His material for the task is more than ample. He has had access to all telegrams and correspondence, to all reports and despatches collected at the Admiralty, and also to information of an analogous character to be found in the archives of the War Office, so far as these materials concern the distribution and action of the Fleet. To judge from the sample before us, the author has sifted this mass of detail with discretion and impartiality. He gives the impression of having thoroughly mastered the facts, and of seeing the whole panorama of the war in its entirety. An illuminating perspective is necessary in order to understand the policy that dictated measures, or to realise the bearing that remote and apparently disconnected events could exercise on momentous decisions. This perspective or preservation of due proportion, Sir Julian supplies with happy results.

The barest outline recalling the conditions that obtained in the autumn of 1914 is sufficient to show the difficulty of maintaining this proportion, and of giving to events near and remote the consideration that is due to each. In the first place, a fitting and commanding position had to be selected for the Grand Fleet and the decision of the Admiralty which banished the Fleet to a distant and little known anchorage was not well received by the public, who did not adequately apprehend the extent of the modification of previous strategy that the geographical position of Germany implied. Gone was the advantage that the English Channel conferred in previous conflicts by reason of its well distributed naval ports and a practically inviolable defile at the eastern end. Germany had equal command with ourselves of the North Sea, and enjoyed protected bases on its borders. An alert foe might utilise the wide outlet between Norway and Scotland for the movement of its ships to destroy our commerce or for the invasion of our coasts. The new conditions required that we should shift the High Fleet base to the North of Scotland, but the whole coast was weak in the special elements that gave strength to the old quarters. Rosyth was inadequate and practically effete before it was finished. The Tyne and the Humber afforded some shelter as river ports, but did not offer the ample space of the inlets on the South Coast. Cromarty Firth and the Orkneys had to provide the necessary accommodation for which no special provision had been made, and much had to be improvised. This removal of the Fleet was very unpopular with those who held that the proper function of the Navy was to seek out the enemy's ships and destroy them at all hazards. The Germans professed to think that our refusal to look for the foe where he most wished to be sought was due to pusillanimity, rather than deliberate judgment, and believed or persuaded themselves that the British Navy had lost its spirit of adventure and fearlessness. No doubt, the proper tactics, less spectacular, but more effective, lay in confining the enemy behind his fastnesses, in covering our own squadrons and flotillas which formed our floating defence against invasion, and in protecting trade. All the enemy's home terminals lay within our home waters, and we could block them by the same disposition of force by which we ensured free access to our own. That these tactics were correct is shown by the immediate and complete paralysis that overtook the German sea-borne trade, a paralysis that was due, not to the operation of our distant cruisers, but to the fact that the position of the Grand Fleet and its subordinate detachments prevented the German mercantile marine utilising their own ports. All this may be admitted now, but it was not at the time, and the Admiralty were much hampered by ill-informed and hostile criticism.

Simultaneously with the maintenance of an incessant watch over an unscrupulous and active foe, provision had to be made for transporting an expeditionary force to the Continent on a scale of unprecedented magnitude. Concentration in the European theatre was a paramount military necessity that could not be delayed, though the demands of the War Office subverted the most cherished naval traditions. The generous assistance of men and material so freely offered from every Dominion and Dependency, from New Zealand to Vancouver, demanded that suitable protection and convoys should be forthcoming, however severely the naval force might be taxed. The trade routes, too, had to be constantly patrolled, and though the plan was sound and deserved to be upheld in face of discouragement, or apparent failure, no doubt the occasional sporadic success of the enemy's commerce raiders interfered with its rigorous preservation. In deference to public opinion, it became necessary, or was thought to be prudent, to watch bases rather than focal points. Looking back on the past, we may be thankful that a well conceived strategy was preserved, and if we can summon up a true picture of the magnitude of the task imposed, in consequence of the tangled web of routes that is the consequence of the enormous volume of trade, and of the slender cruiser force at our disposal compared with the immensity of the ocean in which the enemy cunningly lurked, we shall forget the defects and remember only the brilliancy and the extent of the success. Within ten days of the declaration of war the northern trade routes were so completely secured that the Admiralty could report to Paris "The passage across the Atlantic is safe: British trade is running as usual."

The author undertakes to show in minute detail how these objects were effected, against what difficulties the Admiralty had to contend, the remedies that had to be applied when adverse results supervened, and the degree of success that attended the measures. To accomplish his purpose, it is necessary to unfold the history of those early months of war, and what a history is revealed. More space than is available would be required even to catalogue the principal events of that period: to attempt to describe any is impossible. Shadow and light are intermingled most perplexingly, and high hopes are followed by bitter disappointment. Well-weighed judgments are seen to err and happy chances overthrow well designed schemes. Risky ventures turn desperate situations into brilliant triumphs, and failures supervene on the promise of certain success. Generally there is a bright side even when fate seems to fight most bitterly against naval enterprise. The escape of the Goeben was a dark spot in the early history of the war, but the gloom is relieved by the conduct of Captain Kelly of the Gloucester, who saved his ship and outwitted the enemy by combining audacity with restraint. The same month that saw the Goeben safe in the Dardanelles witnessed the action off Heligoland, in which a much needed enheartening success was ensured only by the exhibition of decision and resourcefulness at a critical moment.

It must be remembered that the work of the Navy was not confined to encounters with the enemy at sea. The divorce from military operations was never complete, and the author describes the part played by the Navy in shifting the military base to St. Nazaire when the Channel ports were threatened by the advance of the German army. Slight reference was made to this co-operation in the newspapers at the time, but it was an onerous undertaking only carried to a successful issue by devotion and loyalty. Almost simultaneously, a squadron was sent for the protection of Ostend and Dunkirk. The operations were carried out under every kind of difficulty, but the ultimate effect was to make certain that the Germans would not be able to reach Calais through Nieuport and Dunkirk. Whatever the temporary or permanent success may have been, it has to be balanced by the loss of the Cressy, Aboukir, and Hogue, a loss that emphatically proclaimed the change that had overtaken naval warfare. The Antwerp defence may be recalled and a regretful remembrance bestowed on Zeebrugge, whose defences were left intact at the earnest solicitation of the military forces, in opposition to the advice of the Navy. The pitiable attempt to conceal the loss of the Audacious is seen in all its ghastly futility. As a ruse to deceive the Turks it was deservedly unsuccessful, and reflects no credit on our honesty or our diplomacy. One turns with more satisfaction to the chase of the Emden, which, though the long immunity of the vessel is much to be regretted for the strategic and economical disturbance it occasioned, was conducted with vigour and chivalry, and each side could recognise in the other many good and seamanlike qualities. The book closes on the dramatic incident of the battle of the Falklands, in which the catastrophe at Coronel was avenged, and we were freed from a menace which hampered military operations even in a distant theatre by the naval concentration involved.

BOOKS RECEIVED.

Scientific Papers, United States Bureau of Standards. No. 349. *Photo-electric Spectrophotometry by the Null Method.* By K. S. GIBSON. [Price 5 cents.] *Technologic Papers, United States Bureau of Standards.* No. 123. *Physical and Chemical Tests on the Commercial Marbles of the United States.* By D. W. KESSLER. [Price 15 cents.] No. 136. *Determination of Free Carbon in Rubber Goods.* By A. H. SMITH and S.W. EPSTEIN. [Price 5 cents.] Washington: Government Printing Office.

Laboratory Manual of Elementary Colloid Chemistry. By EMIL HATSCHEK. London: J. and A. Churchill, 7, Great Marlborough-street, W. [Price 6s. 6d.]

The Running and Maintenance of the Marine Diesel Engine. By JOHN LAMB. London: Charles Griffin and Co., Limited. [Price 8s. 6d.]

The Management Problem. By EDWARD T. ELBOURNE. London: The Library Press, Limited. [Price 4s. 6d. net.]

Tanks in the Great War, 1914–18. By Brevet-Colonel J. F. C. FULLER, D.S.O. London: John Murray. [Price 21s. net.]

Selwyn's Mathematical Tables. Edited by W. ERSKINE DOMMETT, A.F.Ae.S., and H. C. BIRD, A.F.Ae.S. London: James Selwyn and Co., Limited.

Commercial Arbitrations. By ERNEST J. PARRY, B.Sc., F.I.C., F.C.S. London: Sir Isaac Pitman and Sons, Limited. [Price 3s. 6d. net.]

The Journal of the Iron and Steel Institute. Vol. C. Edited by GEORGE C. LLOYD, Secretary. London: Published by the Institute and by E. and F. N. Spon, Limited; New York: Spon and Chamberlain.

Silvanus Phillips Thompson, D.Sc., LL.D., F.R.S. By JANE SMEAL THOMPSON and HELEN G. THOMPSON. London: T. Fisher Unwin, Limited. [Price 21s. net.]

Department of Scientific and Industrial Research. Bulletin No. 4. *Memorandum on Solid Lubricants.* London: H.M. Stationery Office, Imperial House, Kingsway, W.C. 2. [Price 6d. net.]

Waterproofing Engineering for Engineers, Architects, Builders, Roofers and Waterproofers. By JOSEPH ROSS, B.S., C.E. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 25s. net.]

Prove dei Metalli col Metodo dell 'Impronta in Relazione agli Altri Normali Metodi Diretti. By Ing. FRANCESCO FIGARI. Torino: S. Lattes and Co.

The Stresses in Hooks and other Curved Beams. By EWART S. ANDREWS, B.Sc. London: James Selwyn and Co., Limited. [Price 6s. net.]

ASSOCIATION OF RAILWAY COMPANIES' SIGNAL SUPERINTENDENTS AND SIGNAL ENGINEERS.—The sixtieth conference of the above association will be held at the Railway Clearing House, London, on Thursday, May 6 next.

THE LATE SIR CHARLES ALLEN.

We greatly regret to have to announce the death at Folkestone, on Tuesday, the 13th inst., after a long illness, of Sir Charles Allen, V.D., J.P., who took a prominent part in the development of the steel industry, which has been a large factor in the commercial prosperity of the Empire during the past 60 years. Born at Camden Town, London, on January 10, 1851, Sir Charles was the son of the late Mr. William Daniel Allen, of Endcliffe, Sheffield, who was a brother-in-law of, and intimately associated with, Sir Henry Bessemer in all his experimental work, and finally, with the evolution of the Bessemer process of steel manufacture. Indeed, his commercial acumen was a large contributory element in the success of the process, because when Bessemer decided, in 1858, to organise the works at Sheffield, primarily for the demonstration of the commercial efficiency of the Bessemer process, it fell to Mr. William Allen to guide licensees towards success in producing the new material. His son Charles having completed his education at the Commercial College at Halifax, and at a technical college in Germany, spent two years in the Oberbilker Stahl Werke at Dusseldorf in Germany. In 1872 he entered the Bessemer Works at Sheffield, where, in association with his brother, the late Mr. Harry Allen, he contributed his part to the success of the undertaking. About this time the company was made a private limited liability concern, Sir Henry Bessemer subsequently devoting his time to other inventions, while in 1889 the concern was converted into a public company, with Mr. William D. Allen as Chairman. On the death of the latter in 1896, the late Mr. Harry Allen became Chairman, and on his death, in 1899, Sir Charles Allen succeeded to the chairmanship and the full direction of the company. Its phenomenal success, especially in later years, is due, in large measure, to the subject of our memoir.

His commercial activities, however, extended beyond the Bessemer concern, as in May, 1892, he became a director of the Ebbw Vale Steel, Iron and Coal Company, Limited, becoming vice-chairman in December, 1910, and chairman in November, 1914. He was also identified with the Carlton Main Colliery Company, Limited, serving as a director from March, 1905. He became a member of the Iron and Steel Institute in 1905 and was elected to the Council in 1916. Amongst his other responsibilities was a directorship of the Sheffield District Railway and of the old Sheffield and Hallamshire Bank from 1895. On the amalgamation of the latter undertaking with the London City and Midland Bank, in 1913, he was appointed chairman of the Local Advisory Committee.

In all his business associations, he was actuated by a broad sympathy, notably towards his staff and all workers. As a consequence, the relationship between the management of the several firms with which he was connected and the workers was harmonious, and rarely did any difference of opinion develop into any suggestion of conflict. The close association of the Bessemer Company with metallurgical research naturally developed in him a recognition of the value of such work, and every encouragement was given by him in connection with the later developments in this department of scientific activity. He was closely identified with the foundation of the Bessemer Laboratory at the Imperial College of Science and Technology, London, which was founded as a memorial to Sir Henry Bessemer and was handed over to the Governing Body on January 30, 1912.

Sir Charles was an enthusiastic artillery volunteer and, later, territorial officer. From his early days his life interest was almost equally divided between artillery and business. Indeed, if we are not mistaken, he was enticed from his studies of metallurgy in Germany by the prospect of service in the Franco-Prussian war, and he attached himself to an ambulance corps which was present at several of the important engagements, notably at Sedan and Metz, suffering afterwards from enteric fever. In 1880 he took his commission in the 4th West Riding of Yorks, Royal Garrison Artillery, and passed through the Gunnery School at Woolwich in 1882, where he took all the certificates for proficiency. For many years he attended the Shoeburyness Camp. His merit in gunnery was recognised on several occasions by a staff appointment as brigade adjutant. In 1884 he went to Canada in command of a detachment of artillery representing England, which won several prizes for marksmanship, and his part in these successes was recognised by the presentation of a replica of the Queen's Prize for the highest aggregate score in various competitions in Canada. In 1889 he presented a handsome cup for annual competitive practice among the four batteries constituting the corps. He advanced, step by step, as a result of his enthusiasm and activity, becoming Lieut.-Colonel in 1897 and ultimately honorary colonel, obtaining, in June, 1900, the volunteer decoration for long service. He continued his keen interest in artillery, and was a vigorous critic of the War Office in their refusal to recognise the need for equipping our Army with modern artillery. His criticism was eminently justified by the condition of our troops when the Boer War broke out, as no army in the world could be said to be less efficiently armed. At this time he showed alike, his earnestness in connection with the efficient equipment of the service and his patriotism by offering to provide, at his own expense a battery of guns complete, with officers, men, and horses, for the South African War. Notwithstanding considerable official opposition, this offer was accepted by the Government, and the guns were ordered from Sir W. G. Armstrong, Whitworth and Co. Later, however, the War Office announced that they wanted the guns from this firm for the Northumberland volunteer artillery. The action of the authorities at that time was very justly a subject for severe animadversion. Sir Charles' interest in artillery, however, survived the resulting disappointment, and he still continued, not only to support his regiment (which he continued to command until 1909), but, as in former years, willingly to give his services on the various committees instituted by the War Office, notably by Lord Haldane. Lord French and Viscount Esher were two of the many military authorities who repeatedly recognised Sir

Photo by Vandyk.

THE LATE SIR CHARLES ALLEN, V.D., J.P.

Charles' services in connection with the Army. It was a natural consequence that on June 25, 1908, the honour of knighthood was conferred upon him by King Edward. Sir Charles' portrait, by Mr. G. F. Bird, of Chelsea, was presented to him, in February, 1911, by the regiment in recognition of his 29 years' service, during 11 of which he had been in command, a replica being placed in the Officers' Mess at the Artillery Headquarters in Sheffield, where it was unveiled by the Lord Mayor of the day. It was a satisfaction also to Sir Charles that, during the Great European War he was able to devote a large part of the resources of his establishment to the supply of material for the armies at the various fronts. The Bolton Steel Works, which were acquired by the company in 1906, were exclusively utilised for turning out shell steel and gun forgings. Notwithstanding his advanced age, Sir Charles Allen was, in May, 1915, appointed to command the Fifth London Brigade of the Royal Field Artillery, Territorial Force, and was mentioned in the *London Gazette* for special war services.

Apart from his interest in his business and in artillery, Sir Charles did not take much part in public life. He was a strong supporter of the Conservative (and later of the Unionist) party, and lent his aid in many election campaigns. Agriculture, too, claimed his interest.

He was of a genial temperament, with *bonhomie* in his manner, a splendid *raconteur*, and always a delightful companion; he was straightforward in business, a ready friend and a sane adviser.

Sir Charles, in 1882, married Ada, daughter of the late George Lea, of Scarborough. She died suddenly, from a severe attack of diphtheria, on May 21, 1909. His two sons, Lieut.-Colonel Cecil Allen and Major Douglas Allen, saw active service and won further military distinction for the family. Lieut.-Colonel C. Allen went out with the Forty-ninth Division as a staff captain, won the D.S.O., and became, this year, a commander of the Third West Riding Regiment, thus succeeding to his father's post. Major Douglas Allen, who went out with the Sheffield City Battalion, was afterwards attached to the Tank Corps and took part in many actions, winning the D.S.O., and being mentioned in despatches by Sir Douglas Haig. Further, there is one daughter, Mrs. Nora Richardson, with whom, and her brothers and relatives deep sympathy is entertained by Sir Charles' many friends.

INTERNATIONAL STANDARDISATION OF ELECTRICAL MACHINERY.

A BEGINNING has been made towards the introduction of a code of international rules for electrical machinery by the publication of volume I of the I.E.C. Rules for Electrical Machinery by the International Electrotechnical Commission. The rules published were adopted at the plenary meeting of the Commission which was held in London last October. The rules which have been adopted cover so far only limits of temperature and temperature rises, but an appendix to the volume deals with dielectric tests which have been proposed by the Advisory Committee on Rating, but have yet to be presented to a plenary meeting for ratification. The rules so far adopted apply to rotating machines of which the terminal pressure does not exceed 5,000 volts or of which the rated output does not exceed 750 k.v.a., or of which the stator core does not exceed 50 cm. in length axially. They apply to all transformers which are not water cooled. The rules give methods of measuring the temperature rises, both the thermometer and resistance method being employed. The whole procedure and the table of allowable temperature rises are clearly set out and there should be no difficulty in testing a machine or transformer to ascertain if it complies with the rules. The price of the volume is 2s. 2d., and it may be obtained from the General Secretary of the Commission at 28, Victoria-street, Westminster, S.W.1. The extension of the rules as well as the consideration of other matters was carried further at a meeting of the Advisory Committee of the Commission which was held in Brussels from March 27 to 31 last. The rating of larger machines was dealt with as well as graphical symbols and nomenclature. Matters dealt with by the Advisory Committee and recommendations made are not the subject of official adoption until after approval at a plenary meeting. It is proposed to hold the next meeting of the Advisory Committee in Paris in November.

CONTRACTS.—Messrs. Edgar Allen and Co., Limited, have recently obtained the contract to supply the whole of the machinery and plant for a Portland cement factory, which is being erected by the Humber Portland Cement Company, Limited, on the Humber, about 10 miles from Hull. The factory will have a capacity in the first instance of 2,000 tons per week, with arrangements to increase to 3,000 tons.

CARBORUNDUM LINING FOR GAS RETORTS.—In the *Journal für Gasbeleuchtung*, 1919, pages 734 and 735, P. M. Grempe recommends the lining of gas retorts with a water paste consisting of 75 parts of carborundum and 25 parts of water glass, or 85 parts of carborundum and 15 of fireclay, well mixed and agitated. The deposit is allowed to stand for 24 hours, and the retort is then slowly heated. A thickness of 0·5 mm. is sufficient, so that about 1,200 grammes of carborundum will be wanted per square metre of retort surface. These linings have given satisfaction in furnaces for coal, coke and gas-firing; flaws in the retorts are repaired with the same mixtures. The suggestion is, of course, not new. Carborundum-lined muffles have been used in the National Physical Laboratory for years, for instance; but the lining of big retorts is a different thing.

MONOCULAR OR BINOCULAR FIELD GLASSES.—In the course of a long research on the Relative Merits of Monocular and Binocular Field Glasses (Journal of the Franklin Institute, February and March, 1920), E. P. Hyde, P. W. Cobb, H. M. Johnson and W. Weniger arrive at the conclusion that there is in general not much to choose between the two kinds of instruments. The tests concerned visual acuity, perception of brightness (shading) and colours, twilight effect (influence of dim illumination), stereoscopic effect, and further cost and time of manufacture, comfort of use and speed of application in the field. Many observations were carried out by soldiers. The binocular did, in most cases, not give better results than the monocular when applied to the better eye of the observer. As regards stereoscopic vision the binocular is superior; but on a dark background the stereoscopic effect is not absent with a monocular glass. As to cost and speed of production and lightness the monocular has great advantages; the monocular is also more quickly applied to the eye; but the binocular strains the eyes less and makes it a little more easy to pick out an object, to count men, &c. In magnification a binocular of power 6 proved equal to a monocular of 6·27; but the military authorities pay little attention to this point.

HAND SHEARING MACHINES FOR RODS AND SHEETS.

CONSTRUCTED BY THE TANGENT TOOL COMPANY, LIMITED, KEYNSHAM, SOMERSET.

FIG. 1.

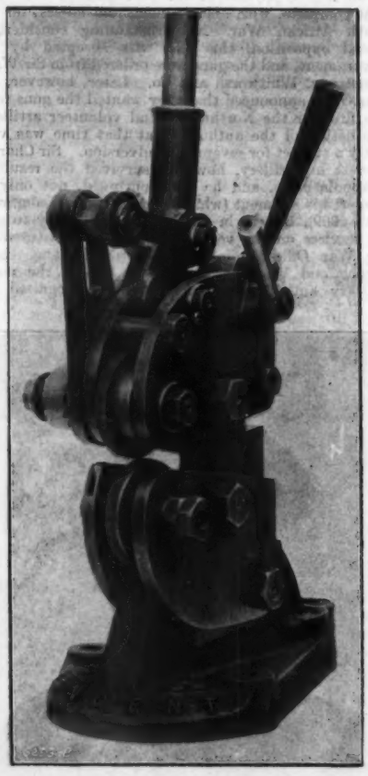


FIG. 2.

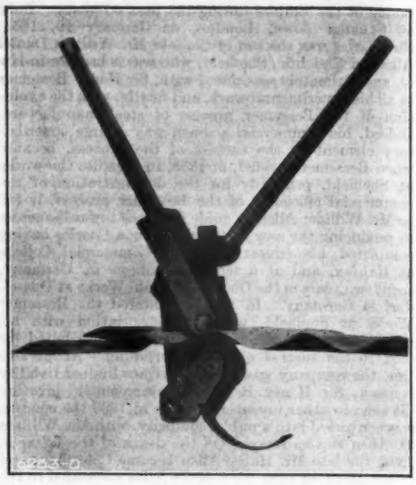


FIG. 3.

WE illustrate on this page several small tools for cutting rods and plates, manufactured by the Tangent Tool Company, Limited, of Keynsham, Somerset. Their design is almost self-explanatory, if the respective illustrations are referred to, but in spite of their simplicity the tools are remarkably effective for their particular purposes and are well worth the consideration of engineers who have use for such appliances. Fig. 1 shows a machine for cutting off round or square rods. It will do very rapid work, especially when large numbers of pieces of exactly the same length are required, as in the case of ferro-concrete reinforcement, &c. A pair of circular dies, one of which is fixed in the frame of the machine, and the other caused to rotate by means of the lever, effect the shearing. Each die has four tapered holes of different sizes to suit different sizes of bar. The opposing faces of the dies are hardened and ground, and they are kept in contact by a hardened fulcrum pin on which the movable one oscillates. An adjustable stop determines the length of the pieces cut off. The dies are readily removed for re-grinding when necessary, and they give a clean and square shear of any work up to $\frac{7}{16}$ in. diameter. The weight of the whole tool is only 17 lb.

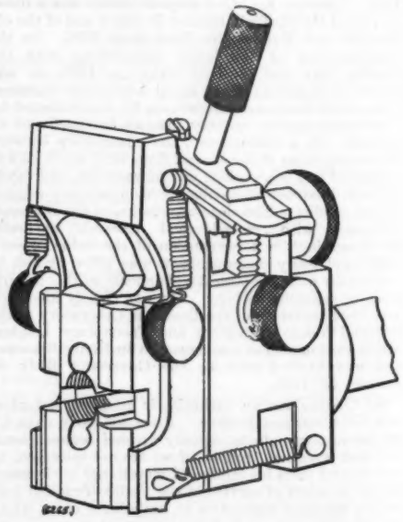
Hand machines for the shearing of sheets are shown in Figs. 2 and 3. The former illustration represents a machine capable of cutting $\frac{1}{16}$ in. steel plates or $\frac{1}{4}$ in. iron plates or any lighter work. The sheet being cut, is fed between a pair of circular shearing tools, the lower of which runs idly, while the upper one is driven by means of a compound lever and ratchet arrangement. Each tool has a milled edge which provides sufficient friction at the surface of the plate to cause the latter to be drawn in and cut. The handle at the side of the machine provides an adjustment of the cutters for various thicknesses of plate, so that they can be set sufficiently far apart to cut the plate without unduly distorting it. When set, the cutters are locked at the required distance by means of the handle at the rear of the machine. The leverage of the machine can be altered by moving the driving pin in the slot of the cutter lever. With the greatest leverage, namely, 56 to 1, steel sheets up to $\frac{1}{16}$ in. thick can be cut with one hand at the rate of about 2 ft. 6 in. per minute. The minimum leverage, which is 36 to 1, permits sheets up to $\frac{1}{4}$ in. thick to be cut at the rate of 4 ft. 6 in. per minute. The weight of the machine is only 60 lb., so that it can be carried to its work and attached to any suitable support.

The cutting of corrugated iron sheets has always been one of the most miserable kind of jobs which a mechanic can have to do. The work is very difficult with ordinary hand shears, and it is noisy, slow and unsatisfactory when attempted with a hammer and chisel. The machine devised by the Tangent Tool Company, Limited, for the purpose, is illustrated in Fig. 3. It weighs only 5 lb., and will cut corrugated iron rapidly and without distortion, either straight across, obliquely across, or on a curve. It has two circular cutters, one free, the other driven by a ratchet motion, and both knurled on their cutting edges. The driven cutter can be adjusted relatively to the other by means of a small screw, and the same screw permits the cutters to be moved apart sufficiently to enable the machine to be withdrawn from the sheet at any point. Thus corners can be cut in a sheet, or angular pieces cut out. The tool is operated by holding one handle and working the other handle to and fro'. It takes very little power, and removes a strip about $\frac{1}{8}$ in. wide from the sheet being cut. For specially heavy corrugated sheet a similar machine is built with compound leverage, but this is only recommended when a considerable quantity of sheets exceeding 20 gauge have to be cut up, as it is, of course, slower than the simple machine. The weight of the compound lever cutter is only $6\frac{1}{2}$ lb.

SELF-OPENING DIE-HEADS.

A SELF-OPENING die-head containing features which render it specially suitable for certain classes of capstan work is illustrated in the figure annexed. The tool in question, known as Lavender's patent self-opening die-head, is manufactured by Messrs. Voucher, Limited, of the Auto Tool Works, Walsall. The dies are of cylindrical section, with flat faces at the front and back, and are brought together by means of the double cam shown in the illustration, which acts directly on the upper die and raises the lower one simultaneously by means of a sort of yoke attachment. To close the dies the knurled handle at the top of the die-head is pulled over, thereby causing the rotation of the cam and the closing of the dies against the pull of the spiral tension springs at the side. At a certain point the handle is held by a catch, the position of which is determined by a micrometer device set by the milled head at the side of the die and graduated in thousandths of an inch. Either one or two cuts can be taken to finish the screw, but the finishing cut is always made with the dies locked in the position determined by the micrometer adjustment, so that uniformity in the size of the finished work can be depended upon.

It will be seen that work can be screwed right up to a shoulder or collar, as there is nothing in front of the face of the dies. The cylindrical form of the latter also permits an extremely accurate fit in the die-head to be obtained, while the dies are also interchangeable and reversible, so that a long life can be obtained. The shape of the die-head is also an important advantage, as it will pass more easily between the tool posts of a capstan lathe than most other designs, and will also clear the saddle more readily. No spanners or other tools are required to change the dies, as these



can be withdrawn and replaced with the utmost ease by withdrawing the knurled pins to which the lower ends of the tension springs are attached.

The Lavender self-opening die-head is made in two sizes for capstan work, the smaller to screw up to $\frac{1}{2}$ in. diameter, and the larger to 1 in. diameter. Whitworth, Square, Buttress, Wood, Acme, British Standard Fine, or other threads, may be cut with equal ease, the multiple cut device ensuring accuracy even with the heaviest work within the capacity of the dies.

SCIENTIFIC AND INDUSTRIAL RESEARCH.—The Secretary of the Department of Scientific and Industrial Research announces that a licence, under Section 20 of the Companies' (Consolidation) Act, 1908, has been issued by the Board of Trade to the Scottish Shale Oil Scientific and Industrial Research Association, which has been approved by the department as complying with the conditions laid down in the Government scheme for the encouragement of industrial research. The association may be approached through Mr. W. Fraser, C.B.E., Scottish Oils, Limited, 135, Buchanan-street, Glasgow.

GROUTING OPERATIONS, CATSKILL WATER SUPPLY.*

By JAMES F. SANBORN and M. E. ZIPSER, Associate Members, Am.Soc.C.E.

GROUTING IN PRESSURE TUNNELS.

THE utilisation of the pressure-tunnel type is one of the notable features of the Catskill Aqueduct. There are nine pressure tunnels, aggregating 35 miles in length. These tunnels were driven in rock, deep beneath the surface, and were lined with concrete averaging from 18 in. to 24 in., and more, in thickness. They have a finished inside diameter varying from 16 ft. 7 in. to a minimum of 11 ft. The depths of the tunnels below the surface vary from 100 ft. to a maximum of more than 1,100 ft., the latter being the depth at the Hudson River crossing. The hydraulic gradient at this crossing is more than 1,500 ft. above the invert of the tunnel. The pressure-tunnel type was adopted only after extended study, as there was no precedent for such tunnels subjected to such high unbalanced heads.

It was the opinion of some authorities that the concrete lining could not be made tight enough against ground-water heads. It was also feared that where the rock was porous and water-bearing, excessive leakage might develop when the tunnel was put in service, and that the application of pressure in the case of jointed and fissured rocks might even cause movement of the rock and rupture of the concrete lining, with resultant outward leakage. Great reliance, therefore, was placed on the use of grout to make the tunnels secure and tight against all leakage.

Design of Pressure Tunnels.—On account of the heavy internal hydrostatic pressures, it was deemed advisable to place the tunnels under a heavy cover of sound rock. This cover is not less than 150 ft., except in the case of comparatively light heads. On account of the external ground-water pressure on the tunnels when they were under construction, or at any time when they are out of service, the circular shape was adopted, and the lining was made thick enough to withstand both the ground-water head and the grouting pressure necessary to overcome frictional resistance and ground-water head. The concrete for the lining was proportioned, mixed, and placed so as to be practically watertight. The concrete lining, in addition to preventing outward leakage, also provides a smooth coating to produce a high coefficient of flow. It also prevents the falling of rock and makes easier the cleaning of the tunnel.

As it was practically impossible in lining the tunnel to pack the concrete tightly against the irregular surface of the rock in the roof, grout was forced in to fill all the voids over the arch and back of the lining and to transmit the internal pressures to the rock. It was expected also that the grout would be effective in closing the seams and crevices in the rock surrounding the tunnel by impregnating any porous, water-bearing strata so as to cut off all subsequent outward leakage.

Conditions Encountered During the Excavation of the Pressure Tunnels.—Before the contracts for the pressure tunnels were let, extensive borings were made to develop the rock profile in the valleys to be crossed and to ascertain the kind and condition of rock to be encountered during the driving of the tunnels. The tunnels penetrate a wide range of geologic formations, the rocks varying in character from a soft shale to hard quartz conglomerate. The most important quality, however, from the standpoint of watertightness of the tunnel, was the soundness and tightness of the rock to prevent outward leakage.

In stretches were the tunnels passed through faulted and crushed zones, and the rock was either unsound or structurally weak, steel ribs and lagging were used to support the roof. At these places the space between the steel lagging and the rock was packed with stone, the dry packing being subsequently grouted through 2-in. pipes set in the concrete lining and extending into the dry packed space.

Although the pressure tunnels were excavated several hundred feet below ground-water level and under rivers and streams, there were only a few stretches where excessive quantity of water entered during the excavation. In many stretches the tunnels passed through blocky ground intersected by joint planes and crevices; the openings in the rock at these places were often found to be filled with deposits of mineral matter, and little or no water entered the tunnels through such openings. Several of the tunnels passed underneath glacial gorges, and the drift overlying the rock formed a dense impervious blanket against the inflow of water. With the exception of the wet stretches of tunnel, to be described in detail later, no cases of inward leakage occurred during the excavation exceeding 150 gallons per minute per mile of tunnel. In the 18 miles of the City Tunnel, the maximum quantity of water which entered the tunnel, was 137 gallons per minute per mile. (See Fig. 1.)

The geological conditions in the tunnels were given careful consideration, as the structure of the rock, the nature of the openings, and other conditions influenced the method of grouting. Underground water circulates in the rock through the intersecting joint planes and seams formed by bending, folding and faulting due to disturbance of the earth's crust. Stratified rocks are often found with alternating hard and soft layers, some of which are quite porous, permitting free circulation either through the body of the rock or along the bedding planes. Vertical planes of fracture are of frequent occurrence in stratified rocks. In the Helderberg limestones large solution cavities or mud seams were encountered, requiring special precautions in making the tunnel secure and providing against subsequent outward leakage.

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All inflowing water from the rock seams was taken care of before placing the concrete lining by collecting the water and leading it through pipes set in the concrete, as will be described later in detail. Subsequently, the water bearing fissures were grouted through these pipes. In many cases, the inward leakage during excavation gradually diminished and often stopped after some interval, due to the discharge of accumulated water in the seam, but the points of inward leakage and the areas of general seepage were carefully noted when the excavation was first made. The locations of wet seams were recorded, and provision was subsequently made for grouting at these places, as it was realised that when the tunnel was in service, water could escape through the same channels whereby it had entered.

GROUTING THE ROCK SEAMS DURING TUNNEL DRIVING TO CUT OFF LEAKAGE INTO THE TUNNEL.

Where large flows of water are encountered in driving a tunnel, a loss of progress invariably results, and very often the work is shut down until additional pumps are installed for handling the water. Obviously, it is of great advantage to reduce or cut off the leakage, if possible, where the inflow is very heavy, before the heading is advanced. As a rule, however, superintendents dislike to stop excavation and grout the wet ground, preferring to continue the driving, if possible. Several efforts were made on this work to cut off the water by grouting the rock during excavation.

Wet Stretch, Rondout Tunnel.—In driving up a 15 per cent. incline north of Shaft 4, in the Rondout Tunnel, a faulted and crushed zone in High Falls shale and Binnewater sandstone was encountered, yielding a considerable flow of water charged with H_2S gas. To shut off the water, an attempt was made to solidify the rock in advance of the excavation by grouting through the drill holes in the heading which flowed water. These holes yielded a flow of about 300 gallons per minute. They were closed with pipes and grouted,

FIG. 1. WET HEADING IN CITY TUNNEL, SOUTH OF SHAFT 4. A FLOW OF 300 GALLONS PER MINUTE CUT OFF BY GROUTING.

but the high pressure used—200 lb. per square inch—blew off 3 ft. of the soft shale in the face of the heading. Additional holes were drilled around the periphery of the tunnel and grouted. Although the leakage was somewhat reduced, the flow increased with the advance of the heading, as additional water-bearing seams were encountered.

On account of the heavily faulted and crushed condition of the shale, which was intersected by wide and narrow seams, it became apparent, after further efforts, that grouting could not be depended on to reduce the leakage materially, and it was then decided to advance the heading without further grouting. After a suspension of nearly three months, during which time a pumping plant having a capacity of about 5,000 gallons per minute, was installed in the tunnel, excavation was resumed. The first shot revealed a large water-bearing crevice to the right of the tunnel yielding about 600 gallons per minute. Numerous other leaks were encountered as the heading was advanced, the total pumpage reaching a maximum of about 2,000 gallons per minute. The inflow of water subsequently gradually diminished to about 1,000 gallons per minute, remaining nearly constant at this figure until it was finally shut off by grouting after the lining was placed.

Better results might have been secured in this stretch if a concrete bulkhead had been used to retain the grouting pressures, although the soft and weak condition of the rock was very unfavourable for grouting. Another reason for failure to cut off the water under the conditions encountered was the difficulty of adjusting the consistency of the grout to both large and small seams. Large seams require thick grout for thorough filling, while thin grout must be used to fill the fine seams. Ordinarily, the consistency of the mix was adjusted to the large seams which have to be filled first. In order to secure the best results, grouting of the large seams should be followed by re-drilling and grouting with fine grout, to fill the narrow seams.

Grouting Water-Bearing Seam, Hudson Tunnel.—In excavating the Hudson Pressure Tunnel, 1,100 ft. below the river surface, a flow of about 500 gallons per minute was encountered in the heading near the East Shaft. A 4-in. pipe was first put in the hole from which most of the water issued, and concreted in place. The pipe was connected to the discharge line in the shaft, and the water was forced by its own pressure to a pump chamber at the side of the shaft 300 ft. above the bottom. Eight horizontal holes were drilled into the heading and plugged with pipes fitted with valves. A concrete bulkhead, 5 ft. thick, reinforced with steel rails, was then built against the face of the heading, the pipes extending through. About 180 bags of neat cement in grout was then forced in through the pipes under pressures up to 700 lb. per square inch. The grout was mixed in a Canniff tank and was discharged by displacing it with water pumped in by a high-pressure plunger pump.

On shooting the heading after the grout had set, there was no increase of water even after passing the seam, which was a narrow, clean-cut, vertical crack crossing the tunnel nearly at right angles and found to be well filled with grout. When the bench was excavated, exposing the seam in the bottom, it appeared to be filled with grout, but after it had been excavated about 13 ft. beyond the point of original leakage, one of the vertical bench holes struck a flow of 110 gallons per minute. This flow disappeared after the next shot, and it is supposed that the hole was plugged by the displacement of the rock. The open condition of the seam in this tunnel made it easy to grout, particularly as a tight bulkhead was provided, retaining the pressure. The rock was firm and hard, and the walls of the fissure did not contain soft rock, which would have blocked the opening and prevented the free entrance of grout.

GROUTING IN PRESSURE TUNNELS AFTER PLACING THE CONCRETE LINING.

With the exception of the two instances just described, where an attempt was made to grout the rock seams at the time of driving, all grouting in the pressure tunnels was done after the concrete lining had been placed. As already suggested, the purpose of this grouting was, first, to fill with grout all void spaces between the concrete lining and the rock so that the internal hydrostatic pressures might be transmitted to the rock without rupturing the lining; and, second, to prevent or reduce the leakage out of the tunnel by forcing grout, under pressure, into the water-bearing crevices in the rock and by impregnating any porous rock surrounding the tunnel.

Placing the Concrete Lining in the Pressure Tunnels.—The concrete lining in the pressure tunnels was placed in three steps: First, the invert or bottom strip, from 4 ft. to 6 ft. wide; second, the side-walls extending up to, or a few feet above, the horizontal diameter and, third, the arch comprising the upper part of the section. The invert was placed continuously, with joints at the end of the day's run, which average about 125 ft., while the side walls and arch were concreted in lengths depending on the lengths of forms used, varying from 40 ft. to a maximum of 150 ft. Steel forms were used for the side walls and arch, the concrete being shovelled behind the forms from platforms resting upon these forms. When the concrete in the arch had nearly reached the top, longitudinal boards were set radially on either side of the top arch plate, and the concrete was banked up on a slope above the boards. Before placing the concrete in the key of the arch, the radial boards were removed and the concrete was shovelled in place in the key by end handling.

The concrete for the tunnel linings was mixed approximately in the proportions of 1 : 2 : 4 in the pressure tunnels north of New York City. The mix, however, was varied as the requirements of the work demanded. In the City Tunnel, a 1 : 1½ : 3 mix was adopted. Portland cement was used in all parts of the work. A moderately wet or plastic mix was used for the entire section, except near the top of the arch, and in the key, where a drier consistency was adopted.

Protection of Concrete from Inflowing Water during Placing.—In order to secure a dense, tight lining, it was considered essential to protect the concrete, while it was being placed and during the time of setting, from running water. The method generally adopted to accomplish this purpose was to place tin or galvanised iron drip pans against the rock so as to collect the water and keep it away from the concrete during placing and setting. The water from the pans ran into the tunnel through weepers, consisting of 2-in. steel or wrought-iron pipes set in the concrete while it was being placed, the pipes being extended through the steel forms by holes cut in them.

In cases of concentrated flows, holes were drilled into the rock seams and pipes were set to collect the water without the use of drip pans, or, in some instances, both deep-seated pipes and pans were used. All flowing pipes and spaces behind the drip pans were subsequently grouted. The drip pans were usually held in place against the rock by nailing the edges of the pans to wooden plugs set in holes a few inches deep drilled for the purpose, and by bracing them from the forms. The space between the edges of the pan and the rock was carefully caulked with oakum or plaster of Paris, or a mixture of cement and plaster of Paris, to prevent the concrete from getting behind the pan and plugging the weeper.

In placing invert concrete, the water-bearing seams were taken care of by placing over them broken stone drains covered with cement bags or sheets of tin, and placing grout pipes so as to have them extend down through the invert concrete and drain. Wherever necessary the water was kept below the top of the broken stone drain by pumping through one of the grout pipes until the concrete had set sufficiently hard. In other cases, longitudinal pipe collectors were laid under the invert, carrying the water to a sump from which it was pumped. There were cases of small springs in the lower part of the side walls, where drip pans could not well be placed. At such places, the grout-pipe was run to a blind drain made of broken stone and covered with empty cement bags and dry concrete.

The drip pans varied in size from 1 sq. ft. to 2 sq. ft.

to a maximum of, perhaps, 150 sq. ft. It was found to be better to use several small pans rather than one large one, in order that the grouting pressures might be applied more directly and thus be more effective in closing up the seams, and also to avoid possible rupture of the lining upon the application of the high-pressure grouting. The pans were usually fitted with two pipes, one at the bottom to drain the water and subsequently for grouting, and the other near the top to act as a vent and aid the circulation of the grout in the pan. Small pans were frequently fitted with only one pipe. A great deal of care and attention was given to the placing of the drip pans and pipes in order to insure a tight concrete and, in addition, to make adequate provision for effective grouting subsequently.

In order to make it unnecessary to cut many holes through the forms for the pipes, it was intended originally to arrange the piping back of the forms so as to use a system of collectors with a few holes cut in the forms at regular places. It was found to be more effective, however, to use short, direct pipes for grouting purposes. There are several objections to grouting through long pipes with bends and other connections; namely, the danger of clogging the pipes, the impossibility of cleaning out the pipes or drilling through holes already grouted for the purpose of re-grouting, and the delays likely to occur in placing an arrangement of pipes with complicated details.

With the steel forms first used, holes were cut for the grout pipes and weepers only where necessary, and after repeated use, the forms were badly cut up. On some of the later work, holes were cut in the forms at standard locations. On one contract there was a threaded hole at the centre of each plate, to which the pipe could be secured. This provided an opening for each 15 sq. ft. of surface, which was adequate for ordinary conditions.

By the methods adopted for placing the concrete and protecting it from inflowing water, during setting, a dense concrete of excellent quality was obtained for the lining of the pressure tunnels. In a test made in the Wallkill pressure tunnel, the lining for a stretch of 180 ft. of ungrouted tunnel was subjected to a pressure of 135 lb. per sq. in. The only indications of seepage through the concrete were a few damp spots. If the concrete in the pressure tunnels had not been of good quality, it would have been extremely difficult to make the grouting operations successful.

Grout Pipes and Weepers.—In placing the concrete in the key of the arch, it is a practical impossibility to pack it tight against the rock continuously in the roof. Furthermore, in setting, it shrinks away from the rock. In order to fill the void space along the top and haunches of the arch, grout pipe were set in the arch concrete at the time it was placed. In some stretches, where the breakage in the roof was very high, the space above the normal thickness of the arch was filled with dry packing which was subsequently grouted. Where steel roof support was used, the dry packing placed between the steel lagging and the rock was also grouted through pipes set in the concrete living.

Grout pipes in the arch were usually placed at intervals not exceeding 25 ft. to 50 ft. along the dry stretches. In the beginning, three pipes were placed at each transverse joint in the arch, one at the centre and one at either haunch, for grouting the joint. These pipes, however, were found to be of little value for the purpose and were dispensed with in later work. Additional pipes were placed at points of high breakage in the roof to serve as vents to prevent the formation of air pockets and insure the complete filling of the voids. (See Fig. 2.)

Both weepers and grout pipes were 2 in. steel or wrought iron, except in one of the tunnels where 1¼-in. pipes were used. The 2-in. pipes are preferable as they do not clog as readily as the smaller ones. The grout pipes were carefully placed and were usually wedged between the forms and the rock, either with a spike or other spacer at the end near the rock. Each pipe was provided, at the end nearest the form, with a standard coupling to which the hose connection was made for grouting. On some parts of the work a wad of oakum was placed in the end of the pipe nearest the rock in order to keep out the concrete. Upon removing the forms it was the usual practice to clean out the pipes by poking a rod into them. To prevent the displacement of the pipes during concreting, it was the practice in one of the tunnels to extend all pipes, the dry ones as well as the weepers, through the forms by means of nipples screwed into the couplings. The nipples had to be removed before the forms were struck.

Low and High-pressure Grouting.—Grouting in pressure tunnels was done in two stages:—(1) Low-pressure and, (2) high-pressure grouting. The purpose of the low-pressure grouting was: (*a*) primarily to fill the void spaces beween the lining and the rock, particularly above the arch, and, at the same time, to form a blanket over the construction joints in the arch; (*b*) to fill the voids in the dry packing where the latter was used; and (*c*) to fill any porous or honeycombed spots in the concrete.

The object of the high-pressure grouting was: (*a*) To cut off the leakage of water into the tunnel and thereby prevent the escape of water out of the tunnel by filling with grout, forced in under high pressure, the crevices and openings in the surrounding rock; and (*b*) to complete the filling of the voids between the lining and the rock, particularly in the high places in the roof, and between the drip-pans and the rock. In general, the procedure followed in grouting was first to grout the space above the arch under low pressure through the pipes set for the purpose, and then to grout, under high pressure, the vent pipes and weepers.

Low-pressure Grouting.

Detailed Description.—The details of the low-pressure grouting differed somewhat on the various contracts, the following description being typical of the procedures finally developed. When a stretch of tunnel was ready for grouting the usual practice was first to grout the arch pipes, beginning at one end of the stretch and working toward the other. The pipe to be grouted was first raked out in order to clean it of any obstruction; sometimes it was blown out with air to clear it. Plug cocks were placed on all pipes to which connections were made. A 2-in. grout-hose connection, equipped with a side vent, was attached to the pipe to be grouted, and batches of grout from a tank grouting machine were then discharged through the hose and into the pipe, by compressed air. The pressure ordinarily used for this grouting was about 75 per sq. in. to 90 lb. per sq. in.

Grouting was continued at each pipe to which connection was made until the pipe refused to take more grout or until the grout had travelled along the roof several hundred feet ahead, when connection was made with another pipe and the process repeated. The distance which the grout above the arch could be forced ahead of the pipe, varied from 200 ft. to 300 ft., and in some cases, where there was a large continuous void space in the roof, it would travel more than 500 ft. It was the usual practice, however, where conditions were normal, to grout the space above the arch by making connections to the roof pipe every 125 ft. to 200 ft.

In charging the grout tank the cement, sand, and water in proper proportions were placed in the tank, and the air was allowed to boil up through the batch to agitate it, while at the same time the batch was generally stirred by a hand paddle, as the air alone was insufficient to mix the materials thoroughly.

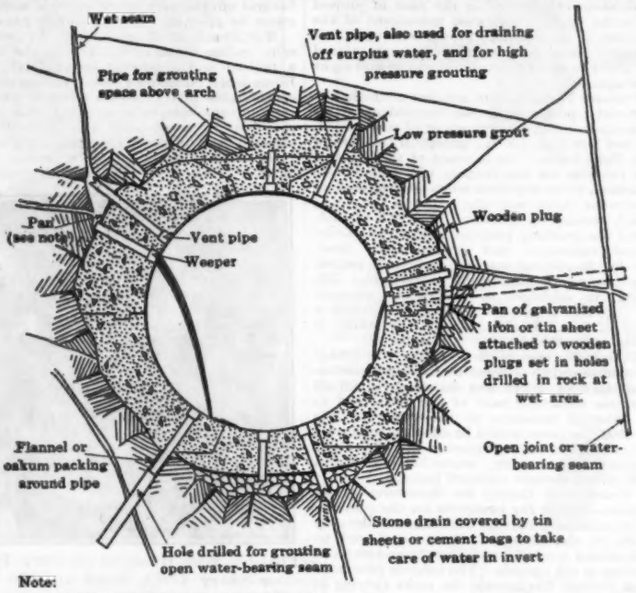
Wet seam
Vent pipe, also used for draining off surplus water, and for high pressure grouting
Pipe for grouting space above arch
Low pressure grout
Wooden plug
Pan (see note)
Vent pipe
Weeper
Pan of galvanized iron or tin sheet attached to wooden plugs set in holes drilled in rock at wet area.
Flannel or oakum packing around pipe
Open joint or water-bearing seam
Stone drain covered by tin sheets or cement bags to take care of water in invert
Hole drilled for grouting open water-bearing seam

FIG. 2.

Note:

Water flowing into the tunnel from the seams in the rock is collected behind drip pans, and drains into the tunnel through 2" pipes set in the concrete while the latter is placed. The concrete is thereby protected from running water during setting. The 2" pipes are later grouted. Holes are also drilled in the rock before placing concrete, to intercept water-bearing seams. These seams are subsequently grouted through 2" pipes placed in the holes as shown.

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PRESSURE TUNNEL.

IN WET SEAMY ROCK METHOD OF TAKING CARE OF INFLOWING WATER AND MAKING PROVISION FOR GROUTING WATER-BEARING SEAMS

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As the batches of grout were forced into the pipe and the grout flowed ahead, water in large streams issued from the adjacent roof pipes; this was the excess water from the grout, as well as the ground-water leakage which had collected above the arch. This water was pushed ahead of the grout, and as soon as the pipes showed a flow of grout they were plugged either by driving tapering pipe plugs into them or, as in the case of the vent or other pipes to which connection was to be made for high-pressure grouting, they were closed by means of the plug cocks at the ends. In some cases, the holes for the connections were plugged by driving a wad of oakum back into the far end of the pipe. At the end of the shift, or several hours after grouting, when the grout had partly set, the oakum was removed with an auger. Any pipe which had filled up with grout that had set, was drilled out for the subsequent grouting.

During low-pressure grouting, the high vent pipes were kept open to drain off the excess water, to permit the escape of air, and to prevent the accumulation of ground-water pressure. During the grouting, the transverse joints in the arch and any porous spots in the concrete generally showed a seepage of water first, then very thin grout appeared, after which the leaks usually stopped in a short time, and silted up. In some cases, the leakage of grout and water through the joints was stopped by driving thin wooden wedges into the joints, and leakage through the porous concrete was stopped by bracing and wedging a board covered with a mat of oakum against the porous spot. The longitudinal joints on either side of the key at the top of the arch also leaked in a few stretches, due principally to porous concrete in the vicinity of the joints.

The weepers from drains and drip-pans, and the deep seated pipes were also kept open during low-pressure grouting. The matter of proper venting and free drainage of the ground-water during low-pressure grouting is of the greatest importance in securing good results, because it is essential not to permit the building up of a ground-water head on the fresh grout since the object is to form an impervious blanket over the top of the arch and thereby prevent leakage of water through the unset grout and the formation of channels through the transverse and longitudinal construction joints or through any porous spots in the concrete.

Grouting Dry-packed Spaces above the Arch.—When grouting dry packing in large void spaces above the arch, hose connections were first made to the lowest pipes, and as the voids in the dry packing were filled and the water drained off, connections were made to the higher pipes. Cases occurred where the vent pipes extended from 15 ft. to 20 ft. in the dry packing above the arch, and at these places grouting was continued until the vent pipes showed a flow of grout, indicating that the dry packing was thoroughly filled. Where water is present above the arch, it is important that the grout should displace the water from below and not be permitted to mingle with it. Samples cut from the grout above the arch showed the grout to be exceedingly dense and impervious, fitting the space without shrinkage and often forming a close bond with the surrounding rock.

Proportions Used for Low-pressure Grouting.—A batch of grout consisted of one bag of cement weighing about 95 lb., one bag of sand weighing generally about 80 lb. to 90 lb., and from 6 gallons to 8 gallons of water, the total making a batch of about 2·0 cub. ft. to 2·2 cub. ft. of liquid grout measured in the tank. The cement was the ordinary commercial brand used for the concrete lining. The sand was very fine, screened, when necessary to meet the requirements of the specifications, namely, that 100 per cent. pass a sieve having 64 openings per sq. in., 45 per cent. pass a sieve having 1,600 openings per sq. in., the wires of the sieves being, respectively, 0·035 in. and 0·013 in. in diameter. In the work north of New York City glacial sand was used, while for the City Tunnel white quartz beach sand from the south side of Long Island was obtained.

The quantity of grout placed depended on the excess breakage in the roof and the extent of the dry packed spaces. In the City Tunnel, in unsupported stretches, where no dry packing was used in the roof, the quantity of grout placed under low pressure varied from 4 cub. ft. to 9 cub. ft. per lineal foot of tunnel.

Progress in Low-pressure Grouting.—The progress in low-pressure grouting varied, usually from about 600 ft. to 1,000 ft. of tunnel a week, working three shifts a day. Many factors influenced the speed, such as the length of haul, the delivery of materials, the proficiency of the gang in loading and unloading of the cars, &c., and, of

course, the volume of space to be filled above the arch. Usually, in normal stretches of tunnel not more than one or two connections were made in 24 hours. The sand and cement were hauled through the tunnel to the grouting plant on flat cars holding from 20 bags to 30 bags. The sand was brought to the work in bulk, but was bagged by hand at the top of the shaft before it was sent underground. Tests were made of handling the sand in bulk in the tunnel, but it was soon found that a package of about the same size and weight as a bag of cement was the most convenient form for rapid handling.

The force employed in the tunnel for low-pressure grouting was generally one foreman and seven or eight men, two charging the grout tanks, one stirring the batch, one operating the valves on the grout tank, and three or four handling the hose and making the connections. On the surface men were employed to bag the sand and load the cars on to the cages.

Precautions to be Observed in Placing Low-pressure Grout.—Low-pressure grout should be injected gently under as low a pressure as possible to avoid churning of the mix and separation of the ingredients, and only a sufficient quantity of water should be used to produce a freely flowing mixture that will not clog the hose. The air pressure should not be higher than necessary to force the grout through the hose and into place. A reducing valve was used on some parts of the work to cut down the line pressure from 90 lb. per sq. in. to 40 lb. per sq. in. and 30 lb. per sq. in. An excess of air, especially when injecting grout under water, is likely to agitate and churn the mix, causing separation and stratification of the sand and cement, with the formation of a soft deposit of laitance at the top of the grout in contact with the rock.

To avoid the after blast of air when grouting a space filled with water, it was the usual practice to close the discharge valve before the hose "kicked," the latter requiring careful watching. A further precaution used to prevent the separation of the mix where a large space filled with water was grouted, was to keep the grouting connection from 2 ft. to 3 ft. below the top of the grout.

The importance of venting the high pipes and allowing all the weepers to run freely during low-pressure grouting has been referred to. It sometimes happens that low-pressure grout enters the drip-pans or drains, but in such cases the pipes should not be kept closed to allow the accumulation of ground-water pressures.

In stretches showing general seepage in the roof of the tunnel, taken care of by drip-pans and pipes, it was sometimes found that the panning was not entirely successful in preventing the water from mingling with the grout. At first, it was thought that these wet stretches should not be grouted with the drier stretches on either side, and they were skipped on the first trip, but it was found that better results could be secured by grouting the wet stretches in the roof with the rest, as the water in the wet stretches did not accumulate pressure, but would travel over the top of the dense unset grout to open vent pipes, sometimes a long distance away, instead of breaking through the grout blanket at a point of near-by weakness.

High-pressure Grouting.

The purpose of the high-pressure grouting, as already stated, was to complete the filling of the voids between the lining and the rocks, and, more particularly, to cut off the flow of water into the tunnel by forcing grout into the water-bearing seams and closing up all openings in the surrounding rock, in order to prevent or reduce the leakage out of the tunnel when the latter is in service.

Detailed Description.—It was the general practice first to grout the high vent pipes in the roof, in order to complete the filling of the space above the arch, and then to grout the pipes from the drip-pans and the deep-seated pipes leading to the rock seams. Some of the vent pipes in the roof showed a flow of water in stretches originally dry. The grouting of one vent pipe would often stop the flow of water from another, indicating a flow of grout through the open seams in the rock. In other cases there would be an increase in the flow of water from a weeper due to forcing water through the rock seams to an open vent. As a rule, very little grout could be injected into the vent pipes.

After grouting the arch pipes the "wet" pipes, or weepers, were next grouted. In starting operations, air at 100 lb. pressure was blown into the pipe to expel the water from the drip-pans or seams. This was sometimes followed by a charge of water to clear the pipe just prior to grouting. The charge of water was often applied as a test to give an idea of the circulation of grout to be expected. If the charge of water failed to "go," the pipe would take very little grout. Another indication of the size and extent of the rock seams that could be reached from a connection was the showing of air at another open pipe or the refusal of the pipe to take air when high air pressure was applied.

The usual practice was to grout the weepers with a mix of 1 bag of cement and 5 gal. to 8 gal. of water. When the pipe would take no more grout, the high pressure, about 300 lb. per sq. in., was kept on it for from 5 min. to 10 min., which had the effect of squeezing the water out of the grout and packing the cement solidly in the pipe. Frequently, if this procedure did not completely fill the pipe, it was drained and plugged with a thick batch of grout. Temporary plugging of a seam during grouting was often overcome by forcing air into the seam under high pressure.

It was found difficult to shut off small leaks through pipes set in the lower portion of the side-walls where no vents were provided. After a pressure of 300 lb. per sq. in. had been maintained on these holes for several minutes, it was often found that no grout had been forced in the pipe and the leak still continued. Such pipes were successfully closed, even in the case of those which flowed several gallons per minute, by driving a tight-fitting wooden plug into the extreme end of the pipe and then ramming with dry cement.

It was the practice on some parts of the work to complete the high-pressure grouting on all the key pipes in the arch in a stretch of tunnel, after which the tunnel was gone over a third time when the flowing pipes were grouted.

Air Pressures.—The pressure used for high-pressure grouting varied, as a rule, between 250 lb. per sq. in. and 350 lb. per sq. in. This was the pressure at the grouting tank. It had to be sufficiently high to overcome the ground-water pressure and, in addition, to force the grout into the seams in the surrounding rock. In the case of very fine seams, the frictional resistance is so great that it is doubtful if much grout is injected into them even under high tank pressures.

Gauge measurements of the rock-water pressure were often taken before the grouting of a flowing pipe was started. The gauge readings, however, gave no clue as to the quantity of grout the pipes would take. The gauge pressures showed that the rock-water level at the pressure tunnels had dropped considerably below the original ground-water level, the gauges registering pressures usually under 100 lb. per sq. in., so that the back pressure was not generally high and the grout was forced in under high net pressures. In many cases, the entire ground-water head was restored a few weeks after the completion of the high-pressure grouting. The grouting of a wet seam in the Hudson River Tunnel has already been referred to. At this location the ground-water pressure before grouting was 475 lb. per sq. in., and the grouting was done under pressures running up to a maximum of about 700 lb. per sq. in.

Mix and Consistency.—To insure the flow of grout into the fine openings, neat cement was used in high-pressure grouting. The consistency of the mix varied, depending on the conditions. Ordinarily, one bag of cement and 5 gallons to 8 gallons of water were used. Where grout could be forced into the rock seams it was mixed very thin—as thin as ½ bag of cement to 30 gallons of water. If this mix was taken freely, it was regarded as an indication that the grout was travelling some distance from the tunnel lining and, therefore, was not of much value. The mix was accordingly thickened gradually by increasing the quantity of cement in the batches until the pipe began to refuse grout, when thin grout was again injected, the pipe being finally plugged with a batch of thick grout under 300-lb. pressure.

Cement.—It was originally contemplated to use very finely ground cement for grouting in order that the grout might be carried readily into the finest seams. However, cement of ordinary fineness of grinding was used, as it was realised that, in time, the openings outside the tunnel lining and through the body of the concrete would silt up. Experiments show that the finer the grinding, the greater the loss in the strength of the grout on account of the more thorough hydration of the cement. The coarse particles impart strength to the cement, and, for that reason, very fine grinding may not be desirable. Some tests were made under severe conditions, using quick-setting Lias lime, but the results were not satisfactory, as the material did not harden properly and the water was not cut off.

Precautions to be Observed in High-pressure Grouting.—A very important factor in successful grouting is the control of the consistency of the mix. For large openings, thick consistencies should be used, while for the very finest openings the best results are obtained with thin grout. The thick mixes, however, must carry enough water to prevent undue clogging. No coarse particle or lumps of cement must be allowed to go into the tank. The cement is sometimes affected by the dampness of the tunnels and should be screened when necessary. Grouting of a hole must be continued without an interruption long enough to clog the hose or permit an initial set of the grout.

(*To be continued*).

Railway Development in Serbia.—It is reported that the Government of the Serbs, Croats and Slovenes contemplate doubling the railway line from the Italian frontier down to the Bulgarian border as an undertaking of imperative necessity, and in this connection it will be necessary to construct bridges over the Theiss, the Danube, the Save and the Drin, in order to link up the new provinces of the kingdom of Serbia proper. These schemes will, it is reported, be undertaken as soon as funds are forthcoming, in respect of which negotiations are now proceeding. Firms interested should communicate with the Minister of Communications at Belgrade.

Irrigation Scheme for Queensland.—A proposal of the Queensland Government to open up the Northern Burnett lands for settlement includes a project for a water conservation and irrigation scheme to be carried out in the upper reaches of the Burnett River. While proceeding from Cania Diggings to Cania Station, the Commission passed through Cania Gorge and observed that Nature had provided a perfect site for damming Three Moon Creek, a tributary of the Burnett, and conserving millions of gallons of water which under present conditions only go to waste. Officers of the Hydraulic Department are engaged in boring operations to get a suitable foundation, and taking levels to see how far the scheme can be extended. Three Moon Creek flows between two huge cliffs, hundreds of feet high, and these converge till they are separated by about 150 yards. The officials consider it a simple task to erect the concrete wall to dam the water between the two huge bluffs. Immense bodies of water can be stored in this dam, and the first section of the work will be sufficient to irrigate 10,000 to 12,000 acres. The dam site is on a higher level than the country to the southward, and it will be an easy matter to reticulate this area. The construction of the dam is to proceed concurrently with the settlement of the adjacent lands.

A MODEL FOR REPRESENTING THE CONSTITUTION OF TERNARY ALLOYS.*

By Walter Rosenhain, B.A., D.Sc., F.R.S., Vice-President (from the National Physical Laboratory, Teddington).

The constitution of a binary alloy can be represented, as is well known, by a plane diagram, in which the compositions of the alloys are usually represented as abscissæ on a horizontal base-line upon which the temperatures are plotted as vertical ordinates. For the representation of systems containing three metals—i.e., of ternary systems—it is necessary to resort to the use of a model in three dimensions. For this purpose, the composition of the alloys is plotted within an equilateral triangle whose three corners represent the three constituent metals. Temperature ordinates erected on this triangle as a base give a model containing a number of surfaces representing the various transformations through which the alloys pass. As a result of researches carried out by a number of authors, both in this country and abroad, the data for the construction of such models, at all events in an approximate manner, have been obtained for a certain number of systems, and in many cases actual models have been constructed. The method of construction which has usually been adopted consists in the preparation of a number of pieces, generally made by casting plaster of Paris in suitably-shaped moulds, and so designed that the surfaces of the various pieces represent the transformation surfaces of the alloys. When the whole of such a model is put together, the upper surface represents the temperatures at which solidification commences, the surface being, therefore, the liquidus of the system. By removing the upper layer of the pieces, lower surfaces, such as the solidus, can be exposed to view.

This type of model, although very useful and instructive, has the very great disadvantage that only one surface or group of surfaces can be seen at one time, and it is difficult to grasp the inter-relation of the various changes which the alloys undergo. An attempt to overcome this disadvantage has been made by the author, and possibly by others, by adopting a method which has proved useful in physiological and zoological studies. Here successive sections of the whole model are drawn or painted on suitably-spaced sheets of glass or celluloid, and these successive sections as seen through the transparent sheets form a general view of the contours of all the surfaces. Unfortunately, however, the transparency of a series of sheets of glass or celluloid is not very great, and there is a very large loss of light by the numerous reflections at the surfaces of different sheets; consequently only a dim vista of the structure as a whole can be obtained, and that only from one side.

An alternative method of constructing such a model occurred to the author, and has been developed with the assistance of his colleagues at the National Physical Laboratory. Models made of wires of various thicknesses and colours have previously been used for the illustration of solid geometry, and it appeared that the same principle could be usefully applied to the present case. In the first attempt only the main outline or ribs of the model were constructed of wire, and it was thought that the surfaces themselves might be satisfactorily represented by coloured threads of cotton or silk stretched between these wires. This proved unsatisfactory for two reasons. In the first place, the accumulative pull of the threads materially deflected the wire ribs; and in the second place, it is obviously impossible by means of threads to represent anything in the nature of convex or concave surfaces such as are frequently met with in these models.

Finally, therefore, the use of fairly substantial wires varying in gauge from 16 S.W.G. to 19 S.W.G. have been employed. An initial difficulty consists in obtaining such wire perfectly straight, as wire is usually produced by coiling it on a drum as it is drawn from the die. The wire, of course, could be straightened by annealing it and stretching it, but fully-annealed wire is undesirably soft for the purpose. For lengths up to 13 in. so-called "silver steel" wire, which can be obtained perfectly straight, has been used; where long pieces have been required brass wire has been employed after being straightened as carefully as possible.

In constructing the model the wires are joined together by careful soldering—an operation for which a small electrically-heated bit has proved extremely successful. As the various surfaces are completed the wires are painted with coloured enamels. A colour scheme has been adopted in which each colour represents one definite phase. The wires composing the top surface or liquidus are therefore coloured with one colour only throughout each field. Frequently the next surface below the liquidus represents the separation of a duplex body corresponding to the eutectic of the adjacent binary system, and here, as two phases separate simultaneously, the wires are coloured with two colours alternating on successive wires. The treatment of these duplex bodies, however, presents a slight difficulty. The binary eutectic is affected by the presence of the third metal in two ways. First, the temperature at which it commences to separate is depressed; and second, instead of becoming completely solidified at one temperature, its solidification is spread over a short temperature range. Consequently, the simple horizontal eutectic line becomes transformed in the ternary model into two sloping or curved surfaces, sometimes lying very near to each other. If the model is constructed on any reasonable scale, two surfaces of this kind frequently lie so close together that they could not be effectively shown as separate. In such cases one may either omit the second surface or exaggerate the separation of the two sufficiently to represent them as distinct. The author has used

* Paper read before the Institute of Metals, March 12, 1920.

both alternatives according to circumstances, but it is important to recognise the character of these duplex bodies and the manner in which they differ from the simple binary eutectic. The author, therefore, suggests the use of the term "binary complex" as preferable to "binary eutectic" where three-metals systems are concerned.

The final solidification of the alloys in many cases takes the form of a ternary eutectic. In the model this is represented by a series of horizontal wires, bearing three colours indicative of the three phases which here

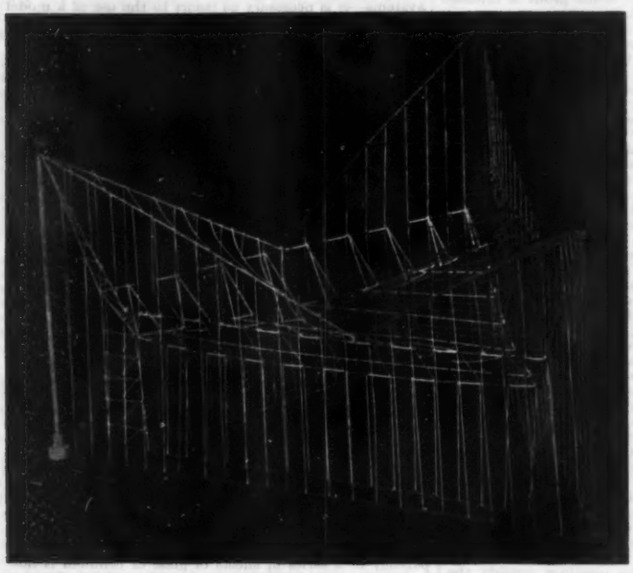

FIG. 1.

separate simultaneously. For vertical divisions between phase-fields, and for the sloping or curved surfaces indicating limits of solid solubility, more or less upright wires are employed having a uniform colour quite different from that representing any of the other phases.

A model of this kind has been constructed, and is illustrated in connection with the accompanying paper on "Zinc Alloys with Copper and Aluminium." That model, however, represents the equilibria of only a relatively small portion of a ternary system. In order, therefore, to illustrate the characteristics of this type of model in a more general manner more readily correlated with the diagrams ordinarily published, a special model has been constructed representing an imaginary complete ternary system, based approximately on the known data for the system lead-tin-bismuth. The data in question, however, do not include the limits of solubilities in the solid phases, and values for these have been assumed. Further, the transformation known to occur in the solid lead-tin alloys has been omitted for the sake of simplicity.

The representation of a model of this kind on paper presents very great difficulties; the value of the model lies in the fact that it permits the simultaneous viewing of a number of different intersecting and superposed surfaces, and the outlines of these, as indicated by systems of wires, are readily followed by the eye in the actual model. Representation by photography or perspective projection, however, meets with the corresponding difficulty that a whole maze of superposed lines produces a certain degree of confusion.

A photograph of the model, seen against a black background, is reproduced in Fig. 1. The peaks of the liquidus surface marked A, B and C respectively, represent the freezing points of lead, bismuth and tin, respectively. The outlines of the three binary systems can be readily followed on the photograph. For the recognition of the various surfaces, however, resort has been had to the device of preparing a set of perspective projections of the model, corresponding in view-point to the photograph of Fig. 1. In each of these drawings, however, only the outlines of the model have been reproduced, while the particular surfaces to be discussed have been emphasised, first by using heavier lines of a distinctive character, for each type of boundary, and second, by shading the surfaces themselves.

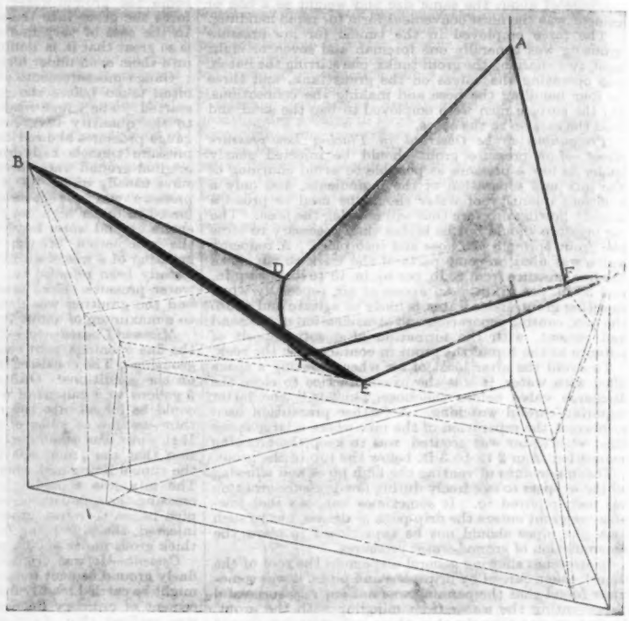

FIG. 2.

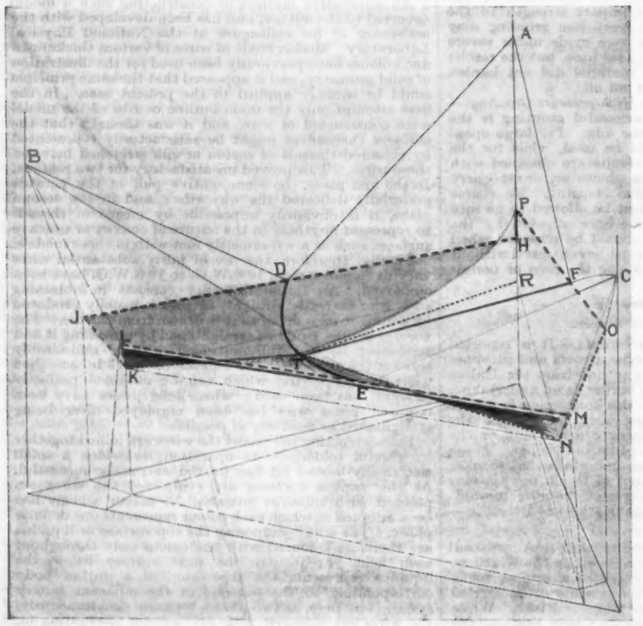

FIG. 3.

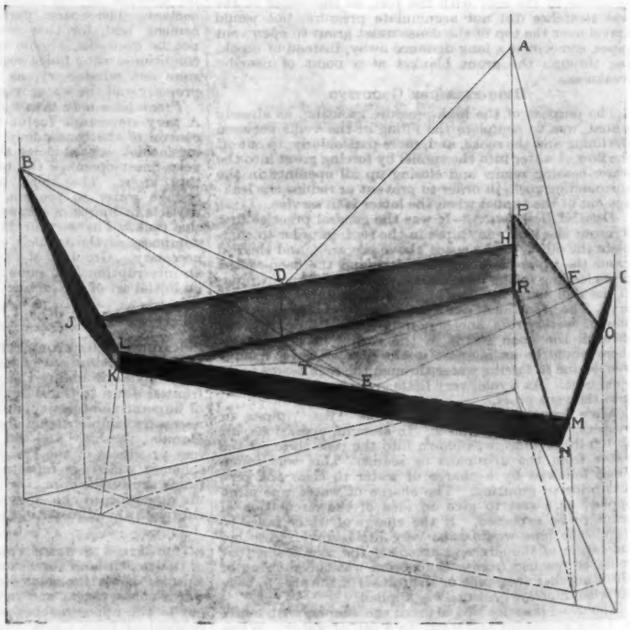

FIG. 4.

Fig. 2 is such a drawing relating to the liquidus surfaces of the model. These three surfaces are bounded by the liquidus curves of the three binary systems, and slope downwards to valleys running from the three binary eutectic points, D, E and F, to the ternary eutectic point. The slightly concave surface B D T E, is seen in the particular projection here employed, partly from the upper side (above the line B E) and partly from below (below the line B E). The surface C E T F, on the other hand, is seen considerably foreshortened.

Fig. 3, drawn in the same manner as Fig. 2, represents the intermediate stage of solidification in which the deposition of the binary eutectics takes place, and the deposition of the "binary complexes" begins. Thus we have the surface H D J K T R, bounded by the

binary eutectic line H J, which slopes down to the lines K T and T R, where it meets the two similar surfaces derived from the two other binary systems. The surface O P R T N is derived from the binary eutectic line O P; as seen in this projection it curves sharply over from the line T F (which lies in the surface) to the line T R. Seen on the solid model, however, the curvature of this surface is not very sharp. Finally, the surface M L K T N is derived from the binary eutectic line L M and slopes down, with very little curvature, to meet the two other surfaces along the lines K T and T N. As shown in the projection, this surface is seen partly from the upper and partly from the under side, according as it lies above or below the line L M, as seen from the view-point selected. In the actual drawing, in order to produce a more satisfactory appearance, this surface is shown as if it had a slight thickness at its edge along the line L E M.

Fig. 4 represents, in the same manner, the solidus surfaces of the system. The plane surface R K N represents the ternary eutectic. At the corner marked R, corresponding to the component A, the model indicates zero solubility. Although theoretically impossible, this condition, which is closely approached in some cases, has been included for illustrative purposes. At J and L we have points corresponding to the limiting solubilities of the components B in the two adjacent binary systems; these points are joined to the point B and to the corner of the ternary-eutectic surface at K by a steeply-sloping surface B J K L, which represents the solidus surface for the solid solution consisting of B containing both A and C. A similar sloping surface, C N M O, is seen, almost end on, at the third corner of the figure.

In all three figures the projections of the various phase-fields on to the equilateral base triangle are clearly seen, and their significance will be readily understood.

The author desires to express his indebtedness to the skill and patience of Mr. J. L. Haughton, M.Sc., Miss G. W. Ford, B.Sc., and Miss A. B. Taylor, in the construction of the model and the preparation of the photograph and diagrams.

ENGINEERING IN DENMARK.—The Burmeister and Wain Shipbuilding and Engineering Company, Copenhagen, has earned a surplus for the year 1919, including the balance carried forward from the previous year, amounting to 5,237,218 kronen, and it is proposed to pay a dividend of 15 per cent. Writings-off and the reserve fund having been provided for, 1,000,000 kronen are set aside for taxes, 500,000 kronen added to the fund at disposal, 500,000 kronen to the pension fund and 250,000 kronen to the workmen's aid fund, a balance of 16,291 kronen being carried forward. The Copenhagen Floating Dock and Shipyard earned last year a surplus of 1,580,000 kronen, of which 433,000 kronen were applied to writing off and 40,000 kronen added to the reserve fund, which now amounts to 1,770,000 kronen. A sum of 400,000 kronen having been reserved for taxation, and the pension fund having been provided, for a dividend of 10 per cent. has been fixed and 26,000 kronen carried forward. The Titan Engineering Company, Copenhagen, again pays a dividend of 10 per cent.; writings-off and reserve fund having been provided for, 85,052 kronen were carried forward

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AMERICAN JOINT COMMITTEE ON STANDARD SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE.—The Joint Committee on Standard Specifications for Concrete and Reinforced Concrete has just been organised. It consists of five representatives from each of the following organisations: American Society of Civil Engineers; American Society for Testing Materials; American Railway Engineering Association; Portland Cement Association; American Concrete Institute. The purpose of the committee is to make a thorough study of all available data on the subject of concrete, concrete materials and reinforced concrete, and to incorporate the most modern information and experience into a general specification which may serve as a pattern for detailed specifications covering specific types of concrete construction. The new "Joint Committee" may be considered as the successor of the "Joint Committee on Concrete and Reinforced Concrete," which was organised in 1904, through the co-operation of the same engineering and technical societies. The original Joint Committee presented its final report to the parent organisations in 1916.

STEEL FOR HAMMER DRILLS.—In the course of the discussion on a paper by Mr. H. S. Potter, recently read before the South African Institution of Engineers, dealing with hammer drills, the author said that when he was first connected with these machines in 1912, the hollow steel mostly used was 0·60 to 0·65 carbon. After working these machines for six to nine months, he found that in the average rock of the Witwatersrand he could not get very long runs; it was therefore decided to raise the carbon content to 0·85 or 0·90, but owing to the difficulties which were encountered where the miners sharpened this steel, it was afterwards brought back to 0·80 carbon. He had a large number of samples of steel tested on this reef and found that they varied from 0·65 to 0·100 carbon, and after considerable consultation with makers of machines which used hollow steel, and also with the makers of hollow steel, and by experiments which he carried out, he thought the best results would be obtained with 0·75 to 0·80 carbon steel. The following is the analysis for such a standard steel: Carbon, 0·75 to 0·80 per cent.; manganese, 0·25 to 0·30 per cent.; silicon, 0·15 per cent.; phosphorus and sulphur, 0·020 per cent.

OPERATING A BY-PRODUCT PRODUCER GAS PLANT.

*Notes on Operating a By-Product Producer Gas Plant for Power and Heating.**

By W. H. PATCHELL, Member.

APART from the three classical papers by Mr. H. A. Humphrey,† there are some scattered articles, but nothing generally and conveniently accessible, on this subject. It is thought, therefore, that some notes on the lay-out and operation of a modern by-product producer gas plant and accessories, and the use of the gas, would be acceptable.

The plant to be described arose out of an investigation as to what was the best form of prime mover for the Hoffmann Manufacturing Company, Limited, to adopt in the next extension of their works. The investigation was made in 1915. At that time Messrs. Hoffmann were using a steam engine and boilers, suction gas engines with anthracite producers, Diesel oil engines, and furnaces—heated in some cases by bituminous coal, and in other cases by anthracite producer gas. Consideration of the then costs of coal and oil, and the fact that the probable user of fuel in connection with extensions then in view would be equivalent to about 60 tons of coal a day, the choice fell on a by-product recovery producer gas plant. The plant selected was on the "Lymn" system which, although much like the better-known "Mond" system, differs from it in important constructional and operating details.

It was arranged to put down the plant in 30-ton units, as, owing to the war, it was thought that the growth of the business, and consequently the need for the complete 60-ton plant, might be indefinitely postponed. The first unit was ordered in July, 1916, but, due to constructional delays, it was not put into operation until August, 1917.

A sudden increase in the business necessitated the ordering of the second unit shortly before the first was put to work. The complete 60-ton plant has now been in operation since March, 1919, but has not yet been worked up to its full capacity.

DESCRIPTION OF PLANT.

Gas Plant.—Before describing the gas plant in detail it may be well to outline some of the essential points in the operation of a by-product recovery gas plant.

The ordinary non-recovery gas producer is supplied with air mixed with a small proportion of steam; the latter is necessary for obtaining good quality gas and also to prevent the formation of clinker. The ammonia formed under these conditions is, to a great extent, destroyed again owing to the high temperatures existing in the producer.

In a by-product recovery producer it is necessary to prevent the destruction of the ammonia, and this result is obtained by introducing a large quantity of steam with the air into the producer; this has the effect of facilitating the formation of ammonia and preventing its destruction by keeping the temperatures in the producer comparatively low.

The amount of steam introduced varies according to the kind of coal in use; from 2 lb. to 2½ lb. of steam per pound of coal gasified may be taken as an average figure.

The provision of so much steam is a serious item in the cost of production, so that as much steam as possible is obtained by utilising the sensible heat of the gases. The method adopted is to cool the gases by contact with water, and to heat up and saturate the air with the hot water so obtained. The process is continuous, the water coming successively into contact with the gas and the air. This results in approximately 0·75 lb. of steam being picked up by the air for every pound of coal gasified, which corresponds to a temperature of about 68 deg. C. saturation.

The balance of steam required, which varies according to the kind of coal in use, is from 1·25 lb. to 1·5 lb. per pound of coal gasified and is blown into the saturated air, thereby increasing the saturation temperature to from 82 deg. to 84 deg. C. Although the calculated amount of steam carried forward with the air may be 2¼ lb. per pound of coal gasified, it is doubtful if such is actually the case.

Steam was required for other purposes outside the gas plant and, in accord with the usual and economical practice, a superheater was included as part of the boiler plant. When using the superheated steam for the gas plant it was found that the air was not saturated to the extent indicated by the thermometer. In order to obtain steadier operating conditions the pipe arrangement was changed and saturated steam was used for the gas plant in place of superheated.

The quantity of steam required for this purpose, and on the plant generally, has a most important bearing on the net coal consumption, so, in order to obtain some data, arrangements were made to isolate one boiler temporarily for this purpose only, and two tests were made, the results of which are given under "Operating Results" later in the paper.

The introduction of such highly-saturated air into the producer would result in cooling the fuel bed below a good working temperature, and to prevent this a regenerator is provided wherein the temperature of the air and steam mixture is increased to about 220 deg. C. before it enters the producers, the necessary heat being obtained from the sensible heat of the hot gases leaving the producer.

The ammonia having been formed passes off with the gases which, after preliminary cleaning and cooling, are brought into contact with sulphate of ammonia liquor containing a slight excess of acid, the excess acid combining with the ammonia in the gas to form sulphate. The process is continuous and periodically, when the liquor is sufficiently concentrated, a portion is drawn off and sent to the stock liquor tanks, water and acid being added to take its place.

"Lymn" System.—Fig. 1, page 530, shows diagrammatically a plant on the "Lymn" system. It may be said at the outset that the whole of the vessels on this system are worked under static conditions, all the washing being done by the movement of the gas and water, unassisted by mechanical means as in the case of most other gas washers.

Fig. 2 shows the general lay-out of the plant. The first two producers installed were those next the river. When the second half of the plant was put up a large "bus" pipe was arranged connecting the two halves of the plant, so that gas from the first pair of producers could be passed through the second set of washers, or from the second pair of producers to the first set of washers, or the whole plant could be run in parallel.

The use of mechanical grates for the producers was considered, but they were not adopted as it was intended to use good coal, and as the number of producers was small it was thought that the extra capital outlay for a mechanical grate would not be justified. Subsequent experience with the "controlled coal" that had to be used went to show that mechanical grates would have been a distinct advantage.

The air, which is supplied by Samuelson blowers, enters the lower part of No. 3 washer, called the air saturator. It will be noted that the upper part of No. 3 is divided off by a diaphragm, the only connection between the two being through a water seal. The water, which is made hot by contact with the gas in the upper part of the vessel, passes through this seal into the air saturator and there meets the air from the blowers. The additional steam which is necessary for a recovery plant is blown into the air main between the air saturator and the regenerator. The warm saturated air is then passed through the regenerator which stands next to the gas producer.

The regenerator, sometimes called a superheater, consists of a nest of concentric cylinders so arranged that the hot gases from the producer and the saturated air pass in counter current. Owing to the large amount of steam which is blown into the gas producer with the air, the working temperature is comparatively low. The gases leave the producer at the top and pass into the regenerator above mentioned, where their sensible heat is given up in part to the air and steam.

The hot gas leaving the regenerator is then passed through a dust trap before it enters the vertical dust washer No. 1, in which the remaining dust is removed as sludge by the washing water. From the top of the dust washer the gases pass down to the bottom of No. 2 washer. In their upward flow through this washer they are brought into intimate contact with a solution of sulphate of ammonia containing a slight excess of sulphuric acid which absorbs the ammonia from the gas.

After the ammonia has been absorbed in No. 2 washer the gas passes through the upper part of No. 3 washer, thence down to the bottom of, and up through, No. 4 washer.

It will be noticed that the design of the Lymn washers differs from other types in that they are free from obstructions in the shape of packing boards or tiles, and from moving parts. The apparatus consists of several vertical cylindrical chambers, No. 1 of which is simply fitted with water jets at the top which fill the vessel with spray through which the gas passes in an upward direction and is thereby washed. Nos. 2, 3 and 4 contain a series of truncated cones. Axially placed in the centre of the apparatus a vertical shaft carries a number of fixed discs opposed to these cones. The water entering at the top is distributed on the topmost disc from which it flows in a film or sheet on to the surrounding cone, thence it falls on to the next disc and so on to the bottom of the washer. The gas passes upwards, counter-currentwise, through the sheets of falling water. By this means the gas and the washing liquids are brought into intimate contact, with a minimum expenditure of energy.

The liquor from each of the various washers falls into its respective tank, from which it is drawn by a centrifugal pump and circulated again through the washer except in the case of No. 4 washer, the hot water from which is put through a water-cooling plant before being recirculated.

In view of the difficulty in obtaining pure lead and its cost at the time the plant was installed, it was decided to depart from the usual practice and not line the ammonia absorber with lead. Several plants had previously been constructed with steel absorbers, and in one case a Lymn plant, erected in Germany, had been at work for over three years prior to the war, without any corrosion taking place.

The gas, after leaving the final cooler No. 4, is passed through two Jenkins centrifugal gas cleaners. These consist of 25 in. diameter centrifugal fans with impellers of a somewhat crude shape; each of them is capable of handling continuously 4,500 cub. ft. of gas per minute against a pressure of 5 in. of water when running at from 1,450 r.p.m. to 1,650 r.p.m.

The amount of power taken is 10 brake horse-power to 12 brake horse-power for each fan with water injection. Approximately 500 gallons per hour of cold water is

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* Paper read before the Institution of Electrical Engineers on Thursday, March 11, 1920.

† "Mond Gas Producer Plant," Institution of Civil Engineers, 1897; "Power Gas and Large Gas Engines," Institution of Mechanical Engineers, 1900; "Generation and Distribution of Producer Gas in South Staffordshire," Institution of Civil Engineers, 1912.

injected into each fan, depending on the class of coal in use and the atmospheric conditions. The tar and water drain away from the outlet pipes of the fans to a settling tank from which the tar is skimmed off.

The gas, after leaving the fans, passes through a water separator of the cyclone type before it goes into the gasholder governor, which is so arranged that, in the event of the gas failing, the supply to the gas engines is cut off before that to the furnaces. This prevents any suction caused by the engine coming on the furnaces, which might lead to an explosion should the gas come on again suddenly.

Gas intended for use in the engines is then passed through sawdust scrubbers to extract the last traces of tar. The scrubbers have been arranged on the usual system in which the gas passes upwards. With a view to facilitating cleaning, arrangements have been made to pass the gas either upwards or downwards in some of the last scrubbers installed. With an upward-flow scrubber the dirtiest material is at the bottom of the scrubber and, when it is necessary to change it, the cleaner layers at the top have to be removed for the sake of getting at the dirty material. In a downward flow scrubber the dirtiest material is at the top and can be removed without disturbing the whole of the packing material from the scrubber.

Each scrubber box is 13 ft. 6 in. by 6 ft. by 5 ft. deep, fitted with four sets of trays which are packed with sawdust and shavings, finishing off with a blanket or sacking to prevent any of the packing material being carried forward by the gas. Drains are provided to carry off any water or tar collecting in the bottom of the box.

It was expected that the centrifugal fan cleaners would have made the gas sufficiently tar-free to be used on the furnaces without the interposition of sawdust scrubbers, but it was found that the small burners and pipes in use led to a small amount of tar condensing in the gas cocks and connections which had to be cleaned out periodically. It was decided therefore to install scrubbers for the whole of the gas.

In large metallurgical furnaces where the burners are formed of refractory nozzles, and the gas is conveyed in large pipes, such freedom from tar would not be necessary. In the present case the furnaces are supplied through pipes down to ¾ in. diameter, and it was not deemed wise to run any risk of blocking them.

Concentrated liquor produced in the ammonia absorber is by-passed from time to time to two stock tanks at the top of the evaporator house. From these tanks it is drawn as required into a vacuum evaporating pan made by Messrs. Fullerton, Hodgart and Barclay. The vacuum is obtained by a Ledward and Beckett ejector.

Sulphate of ammonia evaporators are generally constructed of copper or bronze. The Lymn practice has been to make the casing of chemical cast-iron with the boiling tubes and tube plates of a copper alloy. At the time the plant was ordered it was impossible to obtain bronze tubes. A tube plate of mild steel and solid drawn steel tubes were used on account of expediency. The life of the tubes (No. 13 S.W.G.) and tube plate was ten months, after which the tubes gave out completely. New tubes and tube plate were fitted, the tubes being ¼ in. thick; these have been in operation ten months. Corrosion has taken place at the top end of the tubes and also in the top tube plate round the tubes; it is hoped to overcome this difficulty as the other parts of the plates and tubes are in good condition.

Sulphate of ammonia crystals from the evaporator are dried in a hydro-extractor, made by Messrs. Watson and Laidlaw, consisting of the usual revolving perforated copper basket suspended inside a mild steel casing lined with chemical sheet lead.

Sulphuric Acid Stock.—The sulphuric acid is delivered in tank wagons and discharged by an air lift into a steel tank on the top of the pump-room from which it runs

Fig. 1. SECTIONAL ARRANGEMENT OF LYMN GAS PLANT

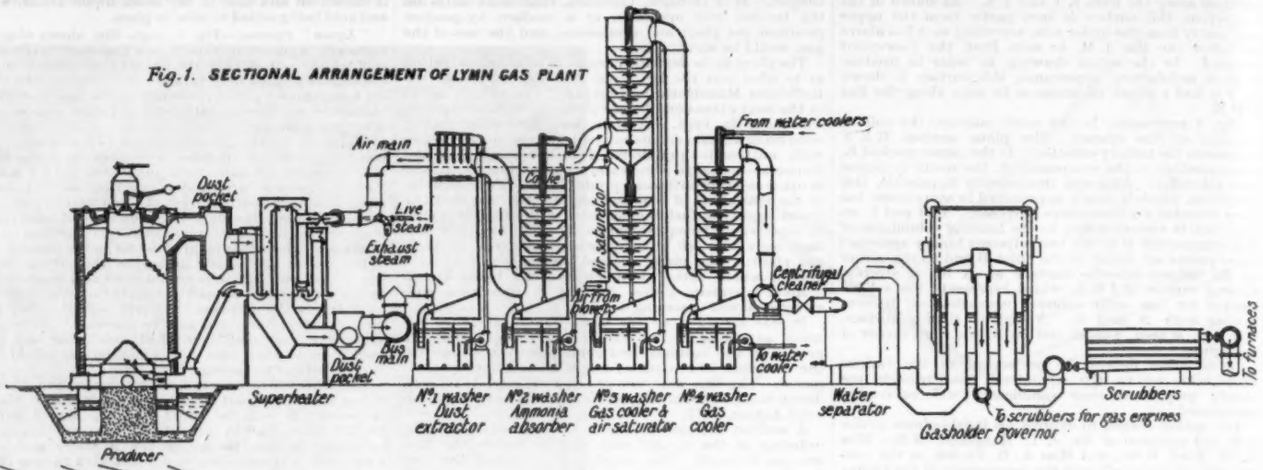
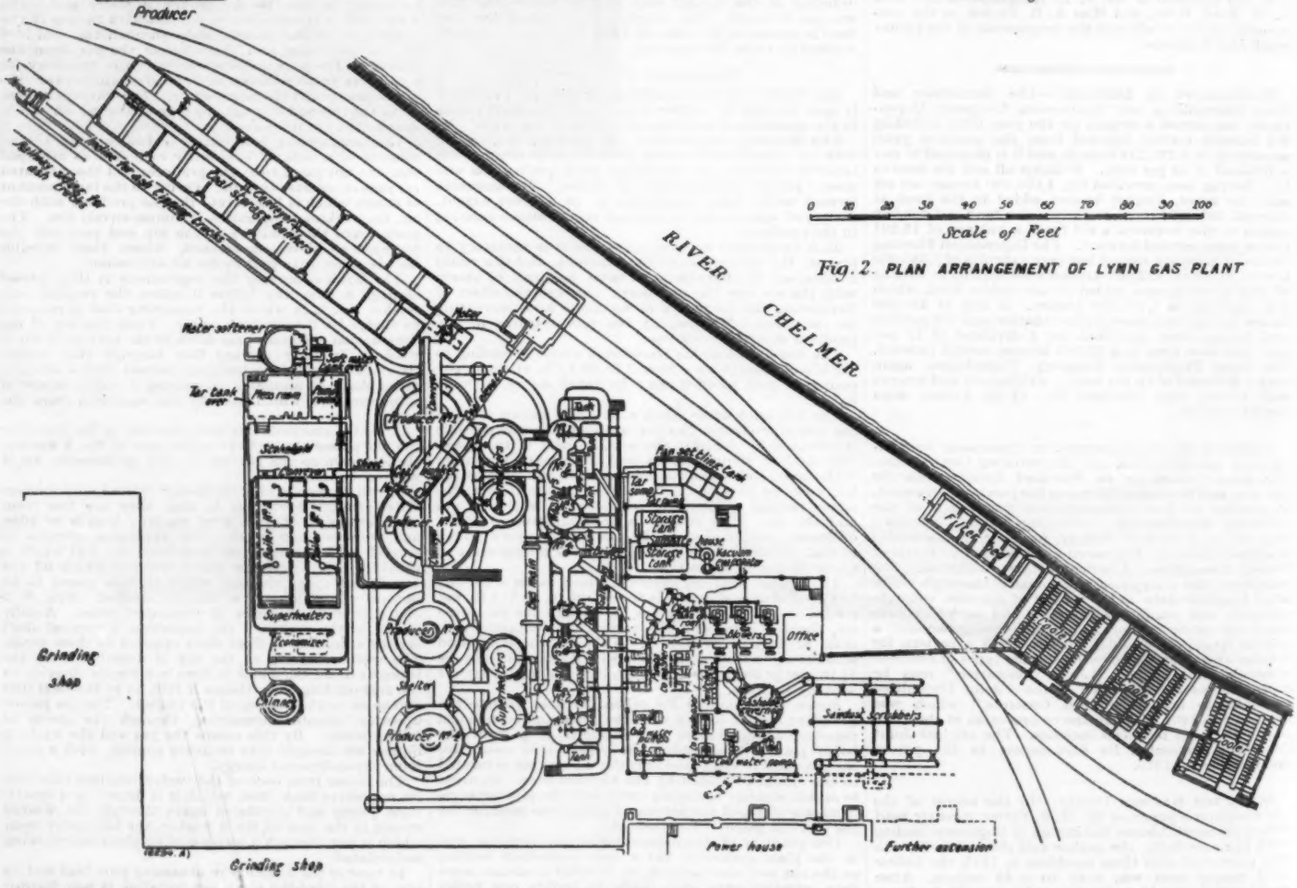


Fig. 2. PLAN ARRANGEMENT OF LYMN GAS PLANT



by gravity through lead pipes to No. 2 washer (ammonia absorber) tanks.

Coal Store.—Coal is delivered by railway trucks to the boot of a Gibbons Brothers' bucket-type elevator, which delivers it on to a band conveyor supplying the 30-ton pockets over the producers, or by a second band conveyor which carries it into the ferro-concrete storage bunker, constructed by Stuart's Granolithic Company. This bunker holds 1,200 tons, and consists of six 200-ton pockets raised on columns sufficiently high to allow 5-cwt. trucks to run underneath.

The band conveyor feeds a push-plate conveyor which delivers the coal into any of the 200-ton pockets as required. When the pockets are empty there is a distance of 40 ft. between the conveyor outlets and the bottom of the bunker. The coal already small, would have been still further reduced in size if allowed to fall from such a height. To prevent this a series of shutes at an angle of 45 deg. are provided, and these carry the coal down to the bottom of the bunker which is also formed at an angle of 45 deg. By this arrangement the coal is stored practically as received, and during filling operations very little dust rises. The bunker is covered with a roof for protection from the weather.

When it is necessary to draw from the storage bunker, the coal is run through valves at the bottom of the bunker into the trucks and thence tipped into the foot of the elevator.

Ash Handling.—The ashes and clinker from the producer lutes are drawn out by long shovels and rakes on to the ground round the producers, which is slightly graded to allow the water to drain back into the lutes. The ashes are then loaded into 5-cwt. trucks running on a narrow-gauge line, pushed by hand a short distance to an incline, up which they are hauled by a small electric winch and tipped into a railway truck or cart according to their destination.

Gas Engines.

Messrs. Hoffmann decided that power units of about 500 brake horse-power would be the most suitable size. The relative merits of vertical and horizontal types were carefully reviewed. The type of engine selected was the multi-cylinder horizontal "Otto" manufactured by the Premier Gas Engine Company, Limited. The floor space occupied is greater than that taken up by a vertical engine, but the sacrifice in floor space is set off by the greater accessibility of the horizontal type.

Another point of difference between the vertical and the horizontal type of gas engine is the speed. The majority of vertical engines run at 250 r.p.m. to 300 r.p.m. In the "Premier" engine the speed adopted is 190 r.p.m., which results in much sweeter working and a quieter engine-room. This four-cylinder four-crank engine is naturally somewhat heavier than a six or eight-cylinder high-speed engine and, to obtain the necessary cyclic regularity for parallel running, a heavy flywheel is used.

A spring-type governor is provided which controls a throttle valve on the gas supply to the engine. The throttle-valve spindle is fitted with a quadrant and pointer showing to what extent the valve is open. With the aid of this the attendant can easily tell if the governor is working freely. It also gives an indication of the quality of the gas by its position as compared with the load.

The air supply is not controlled by the governor, but means are provided for adjusting the amount of air when tuning up; under running conditions it is found that gas governing alone is quite sufficient.

Exhaust Boilers.—Each gas engine is fitted with an exhaust boiler supplied by Messrs. Ruston and Hornsby, Limited. In the case of the first two engines the boilers were installed without water heaters. Water heaters were, however, added to the boilers connected to the later engines. In order to keep down the temperature of the engine-room and to save heat, the exhaust pipes between the engines and the boilers were lagged. Under these conditions the pipes got red hot and were unsafe, so that the lagging had to be removed and the economy due to it on the heat balance sacrificed for other considerations.

In the first two engines installed the exhaust was connected direct to the boiler without a by-pass, so that in the event of the boiler having to be opened the engine would be shut down. This risk, as will be seen from the operation figures given later, was comparatively small; but it was decided in the case of the other four engines to provide a by-pass and, subsequently, the first two boilers were also by-passed.

Dynamos.—Messrs. Hoffmann's works, at the time that the extensions took place, were driven by direct current at 110 volts, and, although it was recognised in the first extension that a higher voltage would be more suitable, it was decided that the first two dynamos should be 110-volt direct-current machines, so as to avoid installing new motors and cables and the nuisance of changing the existing plant.

When the second instalment of plant was put in hand it was decided to use a pressure of 220 volts, as the current was intended for new shops, for which new motors, cables, &c., had to be ordered in any case.

All the dynamos were supplied by Messrs. Crompton and Co., and are open type, direct-current, shunt wound interpole, 360-kw. machines, running at 190 r.p.m. They are provided with a "Hoffmann" roller outer bearing supported in a cast-iron pedestal on a "U" bedplate, and the armature shaft is bolted direct on to the engine flywheel. This makes a very neat and compact arrangement, and has run very well.

Boiler Plant.—In addition to the steam required for the gas plant a large amount is required for heating and domestic purposes in the works, more especially in the winter. This is provided in part by the exhaust boilers fitted to the 500 brake horse-power gas engines. To meet the remaining call for steam two Lancashire boilers were provided, one with the first 30-ton unit and the other with the second.

The Lancashire boilers, 9 ft. diameter by 30 ft. long, were made by Messrs. H. and T. Danks (Netherton), Limited, and are fitted with Hodgkinson's mechanical stokers, a Green's economiser, a Sugden superheater, and feed regulators. These call for no special remarks except in reference to tar burning, which is dealt with later in the paper.

One of Paterson's "B" type cold-process water-softening plants is installed for dealing with the whole of the water required for steaming purposes, as the water available was not suitable. By the use of lime in this plant the hardness of the water is reduced to 3 deg. "Clark" approximately, and the boilers are kept free from scale.

Capital Costs.

Owing to the war the cost of the plant was much above pre-war rates; also, due to the shortage of material and of skilled workmen, the completion of the work was delayed and the cost increased.

Table I shows the outlay per kilowatt.

Table I.—*Capital Cost of Plant per Kilowatt.*

Date.	First Plant. 1916.	Second Plant. 1917.	Average.
	£	£	£
Lymn gas producer plant, without buildings or foundations ..	12·20	14·26	13·230
Foundations and buildings for Lymn gas plant	2·45	2·23	2·340
Coal storage and coal-handling plant (600 tons each)	2·76	2·69	2·725
Building of power houses A, B and C, and engine foundations, cranes	7·30	9·05	8·175
Gas engines, gas pipes, water and compressed air pipes, compressors in power houses	7·75	12·20	9·975
Exhaust boilers with steam, water and exhaust pipe connections ..	1·14	1·99	1·565
Generators, switchboards and connections	5·70	5·98	5·840
Lancashire boilers, chimney, boiler-house and coal-handling plant ..	1·68	1·60	1·640
Total cost per kilowatt	40·98	50·00	45·49

The first installation consisted of a Lymn gas plant capable of gasifying 30 tons of coal per 24 hours, sulphate of ammonia evaporating plant, two 500 brake horse-power Premier-Crompton generating sets, Lancashire boiler, superheater, economiser, chimney, pumps, pipes, feed pumps, 600-ton coal-storage bunker and coal-handling plant, &c.

The second plant was a repetition of the first, except that four 500 brake horse-power Premier-Crompton sets were provided and the gas and electric supply had to be carried considerable distances.

(To be continued.)

Scientists and Income Tax.—A joint committee, consisting of representatives of the Institute of Chemistry the British Association of Chemists, and the National Union of Scientific Workers, has prepared a memorial on the question of the income tax payable by the members of the community who earn their living by scientific pursuits. Within a short time it is hoped to form a deputation to present the case to the Lords of the Treasury. It is claimed that scientific workers are entitled to have many of their professional expenses charged against their income in arriving at an assessment. These expenses would include the purchase of chemicals, instruments, and scientific books; subscriptions to scientific libraries, societies, and periodicals; laboratory rents and expenses. Practising doctors have an allowance for books and instruments; clergymen are allowed an abatement for books and the rent of their studies; and members of the Amalgamated Society of Engineers are allowed it on the purchase, of their tools. At present many scientific workers, it is stated, spend from a third to a half of their income on the expenses of their work, on which they are, apparently, entitled to no relief.

Germany's Export Price Difficulties.—The difficulties with regard to price regulation for German exports, says *The Board of Trade Journal*, are responsible for numerous cases of German cancellation of commercial contracts. The evil is particularly evident in Sweden just at present, and the Swedish Foreign Office have given instructions to their Commercial Attaché to make inquiries regarding the most flagrant breaches. A committee has been formed at Stockholm by the importers of machinery to endeavour to reach an agreement with the German firms. Other importers are being urged in the press to take similar action, and it is also being suggested that the different Swedish Chambers of Commerce should protest. As a result of this press campaign Dr. Fritz Deck, the Stockholm correspondent of the *Frankfurter Zeitung* has written an article in the *Svensk Handelstidning* in which he maintains that the only satisfactory way of doing business with Germany at present is not to fix any prices for other than prompt deliveries, and when the time of delivery has arrived then to fix the prices on the basis of the ruling wages and prices of raw materials. He recommends negotiations between Swedish and German commercial men, and, if necessary, between representatives of both Governments.

CATALOGUES.

Arc Lamps.—An improved arc lamp, which is claimed to give a steady light, of long duration, and with considerable advantages in cost of carbons and trimming, is described in a special catalogue issued by Messrs. Johnson and Phillips, Limited, of Charlton, London, S.E. 7. It is made for continuous and alternating currents and for indoor, outdoor and marine use.

Hauling and Hoisting Gear.—A self-contained electrically driven hauling gear unit for main and tail haulage work, which can also be used as a double drum hoist for shafts or inclines, is described and illustrated in a catalogue received from the Uskside Engineering Company, Limited, of Newport, Mon. It is made in two sizes, of 150 h.p. and 300 h.p. All the parts are closely standardised and made in large quantities, and very low capital and operating costs are claimed.

Heat Treatment.—Automatic and Electric Furnaces, Limited, of 281, Grays Inn-road, London, W.C. 1, send a catalogue of metal furnace pots for their salt-bath furnaces. There are four sizes, from 12 in. deep by 2 in. diameter to 22 in. deep by 10 in. diameter. The cost of current at 1d. per unit and the output in pounds of tools treated per hour are given for each pot. The same firm sends a useful leaflet on the location of faults in the hardening shop, written by F. C. Lantaberry, M.Sc., F.I.C.

Boiler Efficiency.—The Lea Recorder Company, Limited, of 28, Deansgate, Manchester, make an instrument which continually measures, indicates and records the quantity of water evaporated in a boiler plant. The indication is by a plain vertical scale and pointer, and the record is an inked line on squared paper. The catalogues to hand from this firm give the opinions of a number of engineers who use the instrument, and also reproduce a specimen chart based on various qualities of coal and required steam pressures.

Thermostatic Metal.—Thermostatic metal consists of a compound strip of two metals having different coefficients of expansion, in permanent union throughout their entire length. If the strip is straight at normal temperature it will, of course, become curved when heated, and if one end is fixed the movement of the free end over a fixed scale may be employed to indicate temperature directly; or the movement may be used to actuate indicating or recording mechanism. The British Thomson-Houston Company, Limited, of 77, Upper Thames-street, London, E.C., send a catalogue of this metal, which they are able to supply in various sizes for use in making indicating instruments. It may be used up to 500 deg. F.

Heat Treatment.—Messrs. G. P. Wall, of Sheffield, send a second and revised, edition of their bound octavo catalogue of steels, which include mild cold-finished bars, special steels for gears, &c., and a very wide range of tool steels of the ordinary and high-speed kinds. This book is well known both for its useful information and advice on heat treatment, and also for its various tables of equivalents, one of which gives a straight-line comparison between thousandths and fractions of an inch, millimetres, and the four wire gauges, viz., Imperial, Birmingham, Lancashire, and music. A few more pages have been added to the book, and the excellent arrangement and general high-class character of the previous edition have been well maintained.

Steam Turbine Economy.—Where a large amount of heating steam is required, as in chemical, textile, sugar, paper and other works, or in buildings where central heating is installed, a very substantial fuel economy can be effected, provided a supply of electrical current is also required, by generating the steam at high pressure with superheat and using it in a turbine. Of course, the requirements of current and heating steam must be large, and of relative proportions within certain limits. Where such conditions exist the owners and engineers should give careful attention to a catalogue and pamphlet issued by the Metropolitan Vickers Electrical Company, Limited, of 20, Brazennose-street, Manchester (formerly the British Westinghouse Company). The publications describe the Rateau type of mixed-pressure turbine, and discuss fully and clearly the conditions under which the system will effect a substantial economy. In general terms, the turbines work non-condensing, the exhaust going to the heating mains. If the whole of the exhaust can be regularly used irrespective of the load on the generator a back-pressure turbine will suffice. Much more frequently, however, the demand for heating steam varies considerably in relation to the demand for current, and the mixed pressure turbine deals automatically with this condition, as it is capable of working on high, low or mixed pressures. The heating steam is supplied entirely free from oil—a very important feature in all cases and absolutely essential in some.

King's College London Engineering Society.—At a meeting of old students it was decided to form an Old Students' Section of the Engineering Society as a branch of the King's College Old Students Association. The objects are to keep old students in touch with one another and to promote their interests in every way. Mr. C. H. Wordingham, C.B.E., was elected president, and Professor Ernest Wilson and Brigadier-General M. Mowat, vice-presidents. An inaugural luncheon will be held at the Holborn Restaurant at 12.45 p.m., May 1, at which the committee's plans and proposals will be fully explained and suggestions invited from those present. It is hoped that all former students of the engineering faculty will make a point of attending. Further particulars of the association can be obtained from Mr. A. N. Gardiner, 2, The College, Epsom.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

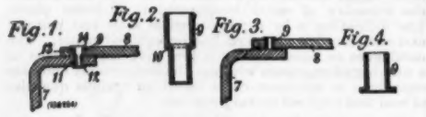
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

136,224. H. N. Wylie, Birmingham. Aeroplane Struts. (5 *Figs.*) December 5, 1918.—The invention relates to the construction of tubes and tubular structures, such as aeroplane struts, and particularly to a method of connecting together a plurality of lengths of metal, papier mache, compressed fibre or other material, of U-shape, channel or like cross-section, to form such structures without external projections. According to the invention, the overlapping edges of the component members are connected together by means of studs or similar projections, which are integrally formed or connected with or independently made fast to one edge and afterwards are made fast to the other



edge by being passed through holes therein and expanded or clinched on its outer side. 8 is fairing in the form of a shell, which is connected to the stiffener 7 along each edge by a row of hollow studs 9. In Figs. 1 and 2, the studs are shouldered or stepped as at 10. The small end is inserted in a hole 11 in the part 7, and is flanged over as at 12 to hold it firmly in position. After a complete row of studs has been fixed to the part 7, the part 8 is brought into position and the big ends of the studs are inserted in holes 13 in the part 8, and are flanged over as at 14. In Figs. 3 and 4, the studs are secured to the part 7 by electric welding. (*Sealed.*)

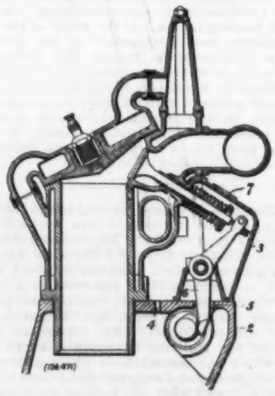
ELECTRICAL APPARATUS.

136,439. C. L. Arnold, Dulwich, and C. R. Belling, Enfield. Electrical Connectors. (3 *Figs.*) April 12, 1919.—A socket tube for wall sockets and connectors has a complete ring of metal at the entry end and a plurality of tongues formed by cuts in the tube which intersect or meet. The socket tube comprises a metal tube 1, of phosphor-bronze or other material, having at the entry end for the pin of the plug part of the connector a complete ring of metal and being belled as shown at 2.

A number of transverse cuts 3, and a longitudinal cut 4 crossing them, are made in the tube, forming two rows of oppositely-disposed tongues 5. Two sets of tongues are preferably provided on opposite sides of the tube. The tongues 5 are pressed slightly inwards. One end of the socket tube is cut away at 11 to accommodate a cylindrical nut 12, and a screw 13 passes through the tube and holds the nut in position. The current-carrying wire is secured by the nut 12. (*Sealed.*)

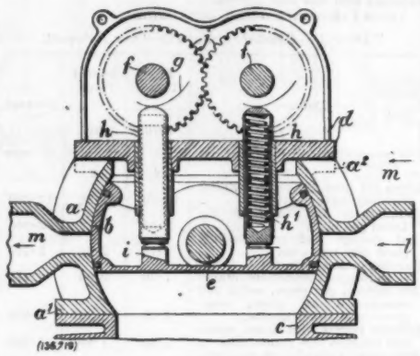
GAS ENGINES, PRODUCERS, HOLDERS, &c.

136,471. S. S. Guy, Wolverhampton. Internal-Combustion Engines. (1 *Fig.*) June 6, 1919.—The object of the invention is to provide for adequate and automatic lubrication



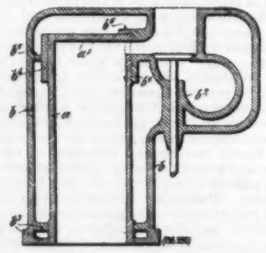
of enclosed valve-operating mechanism and its associated parts. The invention consists in providing the casing enclosing the valve mechanism with openings communicating with the crank-case and outer atmosphere. The openings already provided in the top of the crank-case to accommodate the valve rocker arms may be sufficient to allow of the oil mist entering the casing. The top of the crank-case 2, to which the casing 3 enclosing the valve-operating mechanism is secured, is formed with holes 4, in addition to the openings for the rocker arms 6. The breather orifices 7 are formed in the upper part of the casing 3, and are fitted with gauze caps easily detachable for cleaning purposes. By this arrangement the aspiratory effect produced by the action of the piston on the oil mist in the crank-case causes the said mist to pass through the casing 3 so that whilst the engine is running there is a constant circulation of the oil mist in the said casing. (*Sealed.*)

136,219. D. E. Turner, London, and E. B. Ware, Tottenham. Valves. (2 *Figs.*) December 2, 1918.—The invention relates to valvular arrangements for internal-combustion engines of the kind in which an oscillating spherical or part spherical valve is mounted to oscillate in a head in the cylinder by means of cams. According to the invention, the valve is actuated in its essential movements by cam mechanism, through the medium of tappet rods adapted to bear thereon so as to control the admission of fuel to, and the exhaust of the products of combustion from the cylinder. The hollow spherical casing *a*, carrying the valve *b*, is flanged at a^2 and at a^1, where it is secured to the cylinder *c*. To the flange a^2 is secured a suitable casing *d*, to contain the cam-actuating mechanism. The valve *b* is mounted



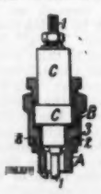
on trunnions *e*. The oscillating movements of the valve *b* are effected by cams *g* mounted on spindles *f*, *f*, passing through and supported by the casing *d* enclosing the cam-actuating mechanism. Each cam spindle *f*, *f*, is provided with a cam *g* adapted to act on a tappet rod *h* supported by the cam casing and interposed between the cam *g* and a projection *i* on the oscillating valve *b*. The tappet rods are telescopic, and the two tubular portions thereof are kept extended by a spring h^1, which is always under compression. The cams *g*, *g*, are arranged centrally of their spindles *f*, *f*, and effect the movement of the valve. The valve spindles *f* are geared together as shown at *j*. The valve *b*, when moved upwards on one side of the supporting trunnion *e*, will admit fuel through the inlet port *l*, and when raised on the opposite side will uncover the exhaust port *m*. (*Sealed.*)

136,288. J. W. Forbes, Sandhaven. Internal-Combustion Engines. (1 *Fig.*) December 18, 1918.—The invention relates to cylinders of internal-combustion engines of the type in which the cylinder proper takes the form of a liner fixed in an outer cylinder adapted with the liner to form a water jacket and having a closed end. The liner *a* fixed in the outer cylinder *b* has its upper end a^1 closed. The cylinder *b*, which is of shell formation, carries a valve chamber b^2. In the lower end of the cylinder are two internal radially-arranged flanges b^3, and near the upper end



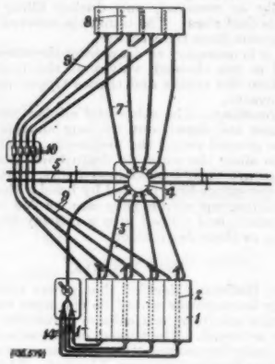
is a short cylindrical sleeve b^4 carried by a perforated web b^5. The flanges b^3 and the sleeve b^4 carry the liner *a*. A suitably-shaped projection b^6 is provided on the sleeve b^4 to form a stop to locate the liner *a* in relation to the cylinder *b*, at such a distance from the upper end of said cylinder as will provide a water jacket over the head of the liner. At the upper end of the liner *a* is a lateral port a^3, which registers with a similar port between the cylinder *b* and the valve chamber b^2. Suitable openings are also provided in the cylinder *b* for the connections to the water jacket. (*Accepted December* 24, 1919.)

136,327. C. C. Bryan, Birmingham. Sparking Plugs. (3 *Figs.*) January 8, 1919.—This invention has reference to sparking plugs of that type in which, to facilitate the cleaning



of the interior of the body, said body is constructed in two or more separable parts screwed together, one of which is the upper part carrying the insulating block and electrode, and the other is the lower part which is screw-threaded to screw into the hole in the cylinder cover. According to the invention, the said lower portion A of the sparking plug body, which is made with a plug to screw into a hole in the engine cylinder, and is also made with an upper tapped socket to receive the upper part B of the body, is made with a top facing 2, and the upper part of said body which screws into the lower part is made with a bottom facing 3, corresponding with the flange or facing on the bottom part, and so as to joint against the same with a jointing washer 8 between, thus making an efficient joint and permitting of the upper part of the body which carries the insulating block *c* and electrode 1 being readily removed from and replaced in the lower part of the body. (*Accepted December* 24, 1919.)

136,579. F. Handley Page, London. Internal-Combustion Engines. (1 *Fig.*) March 15, 1918.—The invention relates to the supply and control of fuel from a number of independent reservoirs to one or more internal-combustion engines. A series of storage tanks 1 are each provided with an independent pump 2, and pipes 3 for feeding fuel to a central distribution chamber 4. From this chamber 4, pipes 5 and 6 connect with the carburettors of the engines, and pipes 7 connect with a series of service tanks 8 situated at a higher level. These tanks 8 are provided with overflow pipes 9, each leading back through an overflow indicator 10 to one of the tanks 1. The



pipes 3 leading from the tanks 1, and the pipes 7 leading from the chamber 4 to the upper service tanks 8, are each separately controlled by cocks. The pipes 5 and 6 conveying fuel to the engines are also provided with regulating cocks, and all these cocks are preferably arranged so as to be under direct control. A hand pump is also provided and connected by a plurality of pipes 14 with the main supply tanks 1, by which means fuel may be pumped from the tanks 1 to the chamber 4 for starting the engines, or may assist in supplying fuel to the engines in the event of one or more of the pumps 2 failing. Each of the pipes 14 may be controlled by suitable valves or cocks. (*Sealed.*)

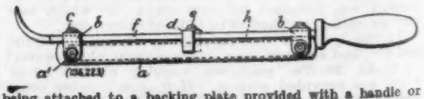
GUNS AND EXPLOSIVES.

17,364/1915. R. Appleyard, London. Boom Defences. (6 *Figs.*) December 10, 1915.—The invention relates to clips, clamps and connecting members for ropes which are specially applicable in the construction of boom defences, submarine defence nets, and the like, where it is essential that there should be a maintained junction between the connecting members and the ropes. The clip or clamp consists of two plates 1, 2, with recesses 11, 21, of suitable configuration to receive the rope,

and to form, when connected together, wedge-like spaces at the top and bottom. The plates are adjustably connected together by bolts and nuts. A pin 3 passes through the rope, and is secured in the plates. A shackle 4 for securing any desired object to the rope, such as net verticals of the jackstay, is mounted and secured to the junction plates by a tubular member 5 bridging the two plates 1 and 2 and receiving the bolt 6 of the shackle, which bolt is screwed into one end of the shackle. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

136,223. J. H. Grant, Erith. Files. (4 *Figs.*) December 5, 1918.—The invention relates to the construction of files composed of narrow steel plates, formed with cutting teeth on one or both edges and clamped together with or without packing strips between, and so that the teeth of the assembled strips constitute the filing surface. According to the invention, the steel plates are united by bolts and removable clipping means in such manner as to leave the exposed sides of the outer blades without projections likely to interfere with the work, the assembled blades



being attached to a backing plate provided with a handle or attached to a hack-saw frame. The toothed blades *a* and intermediate plain strips *h* are fixed together by bolts a^1, which also serve for fixing to the blades, angle strips *b* arranged to embrace a backing *f* for the purpose of attaching the blades to the holder. Clamping screws *e* are screwed into the holder to keep the angle strips *b* in position. Other angle strips *d*, with fixing screws *e*, engage the outer blades at the middle of their length to prevent side spring. (*Sealed.*)